Seedling Survival Study on Abandoned Mine Lands in Eastern Ohio 2000 - 2009

By

Rodney Whiteman
Forester
USDA Forest Service
Morgantown, WV

April 2010

TABLE OF CONTENTS

INTRODUCTION 1

OBJECTIVES 1

METHODS 2

Figure 1- Ohio Seedling Survival Study Areas 3

RESULTS 4

DISCUSSION 16

Figure 2 – EAB Infested Counties in Relation to the Seedling Study Area 18

SUMMARY 21

CONCLUSION 22

APPENDIX A Individual Plot Locations, Slope, Aspect and Directions Along With General Comments 23

APPENDIX B Individual Site and Plot Data 40

APPENDIX C Seedling and Site Photos 78

INTRODUCTION AND BACKGROUND

In the spring of 2000, the USDA Forest Service, the Ohio Department of Natural Resources Division of Forestry and Division of Mineral Resources Management cooperatively implemented a seedling survival study on abandoned mine lands in Eastern Ohio.

By 1972, over 450,000 acres of land in Ohio had been surfaced mined. Poorly regulated mining led to an increase in acid mine drainage, erosion, sedimentation in streams, polluted water supplies and landslides. Nearly 119,000 acres of land were in need of major reclamation efforts. To minimize the impacts of surface mining, the Ohio Mine Reclamation Act was passed. This law regulated active mining sites and required that sites be re-graded to the approximate pre-mining contour of the land, covered with topsoil and successfully re-vegetated, usually with a grass/legume mixture.

In 1977, the federal Surface Mining Reclamation and Control Act was passed and created the Abandoned Mine Lands program. This program addresses problems caused by high priority abandoned mine lands and is funded by a federal severance tax on mined coal. The priority level of an abandoned mine land is based on danger, or potential damage, to public health and safety. Over 8,000 acres have now been reclaimed in Ohio through this federal program.

The Division of Mineral Resources Management developed a reforestation program on abandoned mine lands that are classified as lower priority by the federal program. The goals of this reforestation program is the low cost reclamation of abandoned mine lands, re-vegetation with trees, watershed protection and erosion control. Since 1982, over 6,750,000 seedlings have been planted on 5,640 acres. Successful plantings also increase the aesthetics of abandoned mine lands and creates wildlife habitat. In fact, several abandoned mine lands have been purchased by the State, reclaimed, and are now Wildlife Areas.

With over one million acres of strip-mined land in Ohio and with limited reclamation budgets, it is crucial that this reforestation program is highly successful and problems detected and are addressed when they occur.

This report primarily focuses on green ash, oak species and pine species since they are the most commonly planted seedlings on abandoned mine lands.

This is the tenth year of the seedling survival study and will continue for an additional five years. Since seedling mortality has become fairly minimal, annual visits will not be made. The next visit will be late in the summer of 2014.

OBJECTIVES

- Obtain survival rates for various species of planted tree seedlings on abandoned mine lands in eastern Ohio.
- Obtain and compare species survival rates with respect to soil pH type, slope and aspect, seedling height and reclamation type (un-reclaimed gob pile vs. grassland reclamation).
- Quantify seedling damage, dieback, decline and or mortality by causal agent.

- Based on the results of the study, make recommendations that will improve the overall success rate of this reforestation program on abandoned mine lands.

METHODS

Eight sites located in five eastern Ohio counties (Belmont, Coshocton, Jefferson, Muskingum and Noble) were chosen for the study (Figure 1). Sites #s 1-7 were strip-mined between 1975 and 1982 and represent typical reclaimed areas that have been re-graded, covered with stockpiled overburden and topsoil, and planted in grass/legume mixtures. Site #8 was strip-mined prior to 1972 and was an abandoned gob pile/refuse area. No reclamation had occurred at this site and was essentially devoid of vegetative cover, except some scattered seedlings that had been planted a few years earlier. Mortality of this earlier planting was excessive so re-planting was necessary. Site #1 has an alkaline soil pH while Sites #s 2-8 have an acidic soil pH.

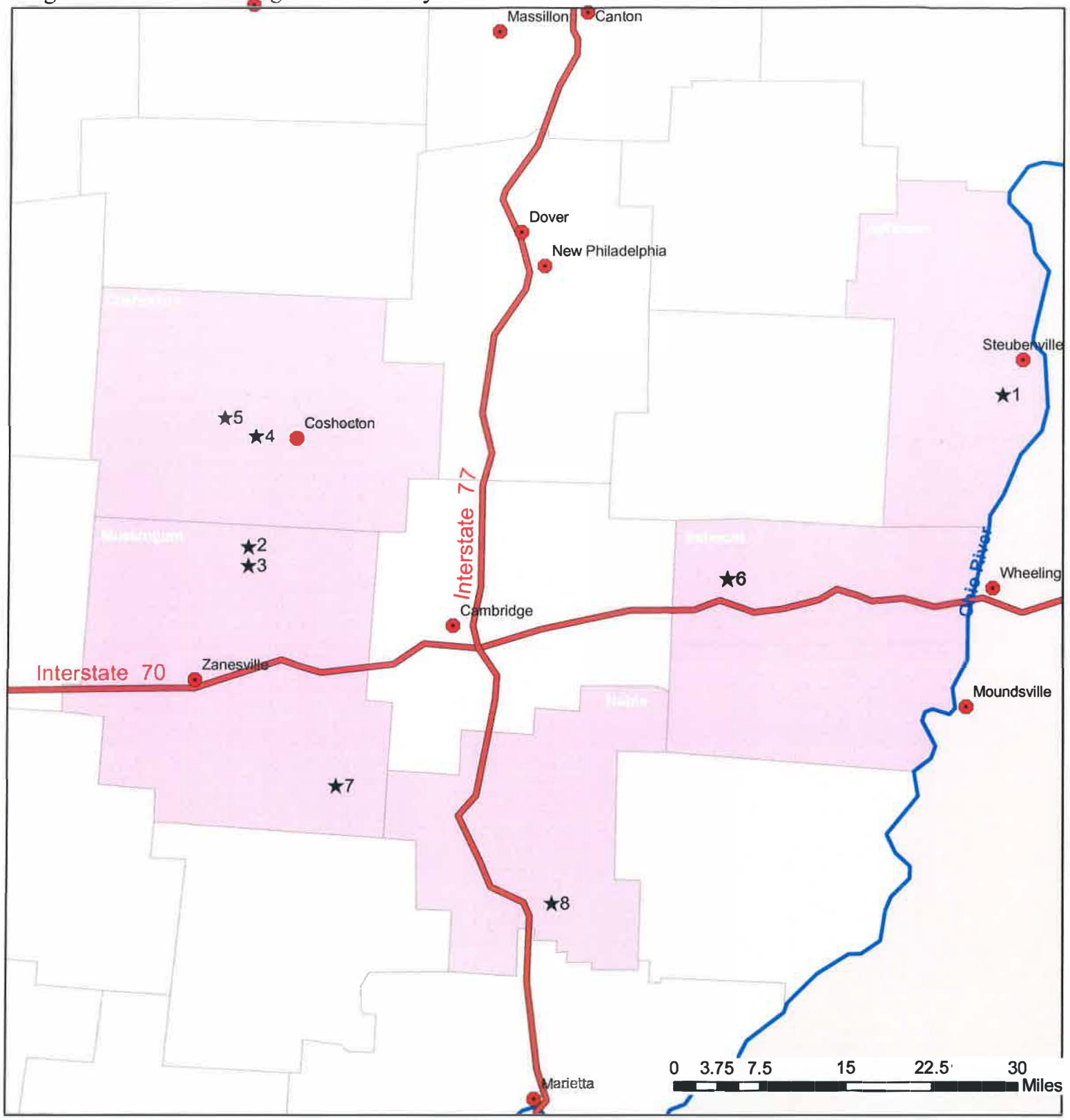
Twelve plots were systematically distributed throughout all of the study sites. At Sites #1 - #7, a plot consisted of a long row (200 feet) of primarily 1-0 nursery grown seedlings that were mechanically planted in the spring of 2000. The beginning and end of each plot were marked with wire flags. At Site #8, several small areas were hand planted in the spring of 2000 with 1-0 nursery grown tree seedlings. Since these areas were less than 200 feet long or wide, each plot at this site was a 30 feet by 30 feet area that was recently planted. All four corners at these plots were also marked by wire flags. Slope and aspect were recorded for each plot at all eight sites. Slope at each plot was categorized as 0-2 percent, 3-10 percent, 10-25 percent or greater than 25 percent. For each plot, aspect was recorded and then placed into one of the following four categories:

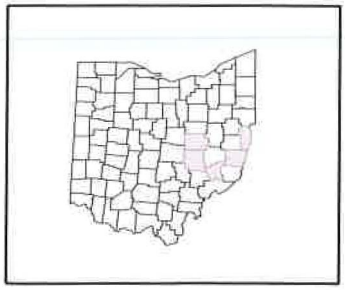
Northern (N)	315.1° - 45°
Southern (S)	45.1° - 135°
Eastern (E)	135.1° - 225°
Western (W)	225.1° - 315°

During the Spring of 2000, directions to each plot were recorded as well as species and location of every seedling in each plot. The plots contained a total of 2,849 seedlings when established. The seedlings were comprised by various oak species (43.8%), green ash (22.8%), Virginia pine (15.2%), Austrian pine (13.3%), black locust (3.0%) and silky dogwood (1.9%). Listed below are the species of seedlings involved in this project along with their scientific name and acronym (used in the tables).

northern red oak	Quercus rubra	NRO
white oak	Quercus alba	WO
shumard oak	Quercus shumardii	SO
northern pin oak	Quercus ellipsoidolis	NPO
sawtooth oak	Quercus acutissina	STO
green ash	Fraxinius pennsylvanica	GA
Virginia pine	Pinus virginiana	VP
Austrian pine	Pinus nigra	AP
black locust	Robinia pseudoacacia	BL
silky dogwood	Cornus amomum	SDW

Figure 1. -- Ohio Seedling Survival Study Areas.





★ Study Areas
● Cities
Major rivers
Interstate Hwys
Study Counties
Ohio
West Virginia

N
W
E
S

USDA Forest Service 3/10

The plots were re-visited twice a year (early spring and late summer) during the first two years and then once a year (late summer) during years 3 through 10. During each visit, seedlings were examined and categorized by the following standards:

Alive and Healthy -	Seedlings that are free from insect, disease and any damage, with no visible abiotic discoloration, and with green foliage (spring/summer).
Alive with Decline / Dieback -	Seedlings that exhibit biotic or abiotic disorders, apparent vigor loss, discoloration of foliage and or small amount of foliage.
Alive with Damage -	Seedlings that exhibit damage to the stem or branches caused by rabbits, deer, mechanical (ATV, other vehicles), etc. If known, the causal agent was also recorded.
Dead -	Seedlings that have no foliage (spring/summer) and have stems that show no active cambium.
Missing -	Seedlings that were accounted for in the initial survey but can not be located during later visit. Most often seedlings classified as missing are not found for two consecutive visits are considered dead.

The height of all living seedlings was measured and recorded in 6″ classes during the visit at the end of the fifth (2004) seventh (2006) and tenth (2009) growing seasons.

During the visit at the end of the tenth growing season, a five foot radius plot was established at each surviving seedling to measure the amount of competing vegetation from woody invasive species, native shrubs and native trees. The species, amount and height of the competing vegetation was recorded for each plot. If there were more than one of a particular species in a plot, only the largest one was measured.

Also during the visit at the end of the tenth growing season, a numbered fiber glass stake was placed at the beginning of each plot at Sites #s 1-7 and in at least two corners of the plots at Site #8. These stakes should be more permanent then the wire flags. A GPS reading was then taken at each stake at Sites #s 1 -7 and at one of the stakes at each plot at Site #8.

The slope, aspect and directions for each plot along with general comments made about the site when the seedling plots were established are presented in Appendix A. An aerial photograph showing the plot distribution for each site is also located in Appendix A.

RESULTS

The overall seedling survival results are summarized by year and presented in the table that follows. The overall seedling survival rate after five growing seasons (2004) was 59.3 percent, during the last five growing seasons the survival rate was 93.2 percent and now averages 55.2 percent. The last five growing seasons percentage was calculated by dividing the number surviving after 10 growing seasons by the number surviving after 5 growing seasons and the multiplying by 100. The lowest annual

survival rate was 85.5 percent during the first growing season and the highest was 99.1 percent during the ninth year. The annual survival rate was 90.4 percent or greater during each of the last eight growing seasons and was 98.1 percent or greater during each of the last 5 growing seasons. The annual survival rate was calculated by dividing the number surviving a particular year by the number surviving the preceding year and then multiplying by 100. The overall survival rate for a particular year was calculated by dividing the number surviving at the end of a growing season by the total number of seedlings planted and then multiplying by 100. For instance, after the sixth growing season (2005) there were 1658 surviving seedlings. Dividing 1658 by 1689 (number surviving previous year) then multiplying by 100 will result in an annual survival rate of 98.2 percent. The overall annual rate at the end of the sixth season would be 58.2 percent (1658 ÷ 2849 x 100).

Summary of annual seedling survival for the 2849 seedlings at Site #s 1-8.

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	2436	2178	2004	1811	1689	1658	1627	1608	1593	1575
overall survival rate	85.5	76.4	70.3	63.1	59.3	58.2	57.1	56.4	55.9	55.2
annual survival rate	85.5	89.4	92.0	90.4	93.3	98.2	98.1	98.8	99.1	98.9

The overall seedling survival results for the seven reclaimed sites (Site #s 1-7) are summarized by year and presented in the table below. The survival rate was 65.2 percent after 5 growing seasons, 93.5 percent during the last five growing seasons and now averages 61.0 percent. The annual survival rate was 90.5 percent or greater each year and was 98.1 percent or greater in each of the last five growing seasons.

Summary of annual seedling survival for the 2460 seedlings at Site #s 1-7(reclaimed sites).

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	2762	2057	1903	1723	1605	1575	1545	1527	1515	1500
overall survival rate	91.9	83.6	77.4	70.0	65.2	64.0	62.8	62.1	61.6	61.0
annual survival rate	91.9	90.9	92.5	90.5	93.2	98.1	98.1	98.8	99.2	99.0

The overall seedling survival results for the un-reclaimed site (Site #8) are summarized by year and presented in the table below. The overall seedling survival rate was 21.6 after 5 growing seasons, 89.3 percent for the last five growing seasons and now averages 19.3 percent. The annual seedling survival rate was less than 50 percent for the first year but was 96.2 percent or greater in each of the last five years.

Summary of annual seedling survival for the 389 seedlings at Site #8(un-reclaimed site).

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	174	121	101	88	84	83	82	81	78	75
overall survival rate	45.2	31.1	26.0	22.6	21.6	21.3	21.1	20.8	20.1	19.3
annual survival rate	48.2	68.8	83.5	95.5	87.1	98.8	98.8	98.8	96.3	96.2

The seedling survival results for each species are summarized by year and presented in the tables that follow. All the oak species are clumped together in a single group. Oaks were planted on 6 reclaimed sites (Site #s 1, 2, 3, 4, 5 and 6) and the un-reclaimed site (Site #8). At the end of 10 growing seasons, oak survival was 56.4 percent. The survival rate of the 1234 oaks planted on the reclaimed sites was 57.2 percent while the survival rate of the 22 oaks planted on the un-reclaimed site was only 13.6 percent. The annual survival rate of oaks was 92.6 percent or less in each of the first five years and was 97.1 percent or greater in each of the last five years.

Annual seedling survival information for 1256 oak seedlings planted at site #s 1, 2, 3, 4, 5, 6, and 8

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	1142	1014	939	862	782	764	742	728	719	709
Overall survival rate	90.9	80.7	74.8	68.6	62.3	60.8	59.1	58.0	57.2	56.4
Annual survival rate	90.9	88.8	92.6	91.8	90.7	97.7	97.1	98.1	98.7	98.6

Green ash was planted on five reclaimed sites (Site #s 1, 2, 3, 5 and 6) and had the highest survival rate for any species after 10 growing seasons at 86.3 percent. The annual survival rate was 97.1 percent or greater each year and was 99.0 percent or greater in each of the last five years.

Annual seedling survival information for 646 green ash seedlings planted at site #s 1, 2, 3, 5, and 6

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	638	624	610	594	577	573	567	565	561	557
Overall survival rate	98.8	96.6	94.4	92.0	89.3	88.9	87.8	87.5	86.8	86.3
Annual survival rate	98.8	97.8	97.8	97.4	97.1	99.3	99.0	99.6	99.3	99.3

Silky dogwood was planted on two reclaimed sites (Sites #s 3 and 6). The survival rate after ten growing seasons was 67.9 percent. The annual seedling survival rate was 92.5 percent or greater every year. In year seven and nine the annual survival rate was 100 percent, although this was based on only 39 seedlings in 2007 and 38 in 2009.

Annual seedling survival information for 53 SDW seedlings planted at site #s 3 and 6

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	49	46	43	42	40	39	39	38	38	36
Overall survival rate	92.5	86.8	81.1	79.2	75.5	73.6	73.6	71.7	71.7	67.9
Annual survival rate	92.5	93.9	93.5	97.7	95.2	97.5	100	97.4	100	94.7

Virginia pine was planted on the reclaimed Site #6 and the un-reclaimed Site #8. The survival rate after ten growing seasons was only 16.7 percent. The survival rate on the un-reclaimed Site #8 was 25.6 percent while on the reclaimed Site #6 the survival rate was 0 percent. The annual survival rate was 80.6 or less in each of the first four years and was 91.9 percent or greater in each of the last six years.

Annual seedling survival information for 430 VP seedlings planted at site #s 6 and 8

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	283	228	161	86	79	78	76	75	74	72
Overall survival rate	65.8	53.0	37.4	20.0	18.4	18.1	17.7	17.4	17.2	16.7
Annual survival rate	65.8	80.6	70.6	53.4	91.9	98.7	97.4	98.7	98.7	97.3

Austrian pine was planted on the reclaimed Site #7 and had a ten year survival rate of 53.2 percent. The annual survival rate was the lowest during the first year at 82.5 percent and was 99.5 percent or higher each of the last four years. Austrian pine had a 100 percent annual survival rate in 2009.

Annual seedling survival information for 378 seedlings planted at site #7

	Year									
	#1 (2000)	#2 (2001)	#3 (2002)	#4 (2003)	#5 (2004)	#6 (2005)	#7 (2006)	#8 (2007)	#9 (2008)	#10 (2009)
# of surviving seedlings	312	264	251	227	211	204	203	202	201	201
Overall survival rate	82.5	69.8	66.4	60.1	55.8	54.0	53.7	53.4	53.2	53.2
Annual survival rate	92.5	84.6	95.1	90.4	93.0	96.7	99.5	99.5	99.5	100

A total of 86 black locusts were planted in the un-reclaimed Site #8. All were dead by the end of the third growing season.

In addition to seedling health, height was also measured at the end of the fifth (2004) seventh (2006) and tenth (2009) growing seasons. This height information is summarized by species and is presented in the table below. The overall average has increased from 2.5 feet in 2004 to 3.8 feet in 2006 and finally to 6.3 feet in 2009. Average height has increased 1.3 feet over the two year period from 2004 to 2006 and 2.5 feet over the last three year period. Average height growth has been accelerated on all species from 2006-2009 when compared with growth from 2004-2006. Seedlings/trees now range in height from 6 inches to 20.0 feet. Virginia pine has had the largest average height in 2004, 2006, and 2009 and has been the species with the largest seedling/ tree all three times. At the end of the tenth growing season, Austrian pine had the second largest average height followed by oaks, green ash and last was silky dogwood.

Five, seven and ten year height measurements by species

Species	2004 Height (in feet)		2006 Height (in feet)		2009 Height (in feet)	
	Range	Average	Range	Average	Range	Average
GA	.5-5	1.95	1-5.5	2.55	1-13	3.75
Oaks	.5-5.5	2.8	.5-9.5	3.85	.5-16.5	7.35
SDW	.5-4	1.45	.5-4	1.65	.5-3	2.15
VP*	1-9	4.45	1-13	6.95	.5-20	10.5
AP*	1-4	2.45	1-6.5	3.4	.5-12	8.75
All species	.5-9	2.5	5-13	3.8	.5-20	6.3

* = based on only one site
AP was only planted at one site
VP was planted at two sites. Only one site had living seedlings by 2004.

Seedling survival and height information is summarized for each site by species and plot in the tables in Appendix B. Site specific information follows.

Site # 1 – Fernwood State Forest

The overall survival rate for the site is 53.4 percent. Green ash survival was 90.6 percent the first five growing seasons, 95.6 percent for the last five growing seasons and now averages 86.6 percent while northern red oak survival was 29.4 percent after the first five growing seasons, 41.6 percent for the last five growing seasons and now averages 12.3 percent. Only 20 of the 151 oak seedlings planted are still alive. This site had the lowest oak survival rate of any site where oak was planted. Even the un-reclaimed Site #8 had a higher oak survival rate than this site. This 74.3 percent difference in ten year survival rates between green ash and oak is by far the largest at any site.

The six plots with green ash all had a survival rate of 77.4 percent or greater while the six oak plots all had a survival rate of 28.6 percent or less. Three of the oak plots had a survival rate less than 10 percent.

A one hundred percent annual plot survival rate (100% APSR) is obtained when all the seedlings in a plot survive from the end of one growing season to the end of the next growing season. Looking at the table for Fernwood State Forest for plot # 1, it had 100% APSR in 2000, 2004, 2006, 2007, 2008 and 2009. Looking at green ash for the first five growing seasons, there are a total of 30 plot years (6 plots x 5 years) with 19 (63.3 %) of them having a 100% APSR . Green ash had a 100% APSR of 76.7 percent during the last five years. Northern red oak had a 100% APSR of 10 percent the first five years and a 53.3 percent the last five years.

Average seedling height at the end of 10 growing seasons is 2.6 feet for green ash and 1.4 feet for northern red oak. The overall average is 2.5 feet. This site had the lowest average height for oaks of any of the seven sites where oaks were planted.

There are approximately 37 Autumn olive (*Elaeagnus umbellata*) per acre and 9 multiflora rose (*Rosa multiflora*) per acre. Average height is 4 feet for the Autumn olive and 5.5 feet for the multiflora rose. Black locust was more numerous than either of these two invasive species as there are approximately 243 black locusts per acre. This black locust can be seen in the aerial photograph for this site. Average height of the black locust is 9 feet. It was interesting to note that seedlings near black locust had an average height of 2.85 feet while seedlings not near black locust had an average height of 2.35 feet.

No damaging agents or damage were detected in any seedlings during the ten year period. However, decline/dieback was detected on 131 seedlings over the 10 year period. (note – decline/dieback was only counted once for a seedling over the 10 year period. For instance, if decline/dieback was noted on an individual seedling twice, it would be counting as a seedling with decline/dieback not two seedlings with decline/dieback). Decline/dieback was detected on 31 green ash, 6 of which died. Average height of the other 25 green ash was 1.9 feet compared to 2.7 feet for green ash that never had any decline/dieback. Decline/dieback was detected on 100 northern red oak, 87 of which died. Height was virtually the same (1.45 vs. 1 .4) for northern red oaks with and without dieback.

Site # 2 – Tri Valley Wildlife Area # 1

The overall survival rate for the site is 88.4 percent. Green ash survival rate was 89.4 percent for the first five growing seasons, 96.6 percent for the last five growing seasons and now averages 86.4 percent. Oak (northern red and white) survival was 89.3 percent for the first five growing seasons, 99.5 percent for the last five growing seasons and now averages 88.9 percent. This was the only site where both green ash and oaks were planted that oak survival is greater than green ash survival.

The survival rate for both ash plots was nearly the same (86.2% vs. 86.8%) while the plot survival rate for oaks ranged from 85-96.9 percent.

Green ash had a 100% APSR of 80 percent in both the first five growing seasons and the last five growing seasons. Oaks had a 100% APSR of 56 percent in the first five growing seasons and 98 percent in the last five growing seasons.

No seedlings died at the site in 2005, 2007 and 2009. Only three have died over the last five years.

The height of the green ash now averages 3.45 feet while the oaks average 8.5 feet. All the oak plots have an average height of 6.3 feet or greater.

Rabbits damaged 74 percent of the green ash and 5 percent of the oaks during the first growing season. Rabbit damage the last nine years has been minimal. Very few of the seedlings damaged by rabbits have died.

There are approximately 8 Autumn olive per acre and 10 multiflora rose per acre. Average height is 5 feet and 5.5 feet, respectively.

Decline/dieback has been detected on two ash and 24 oaks over the ten year span. One of the ash died along with 5 of the oaks. The average height of the oaks with decline/dieback (either past or present) is 3.35 feet while it is 9.0 feet for oaks with no decline/dieback.

Site #3 – Tri Valley Wildlife Area # 2

After 10 growing seasons, the overall survival rate is 72.4 percent. Green ash survival for the first five years was 93.2 percent, 98.8 percent for the last five years and now averages 92.0 percent. Northern red oak had a 69.9 percent survival rate the first five years, 97.3 percent survival rate the last five years and now averages 67.1 percent. Silky dogwood had a survival rate of 63.6 percent during the first five years, 76.9 percent survival rate the last five years and now averages 45.5 percent.

The lowest site annual survival rate was 78.8 percent in 2003. All the other site annual survival rates were 95.9 or greater.

Not counting the two plots where only a single green ash was planted, a combination of green ash and either northern red oak or silky dogwood was planted in the 6 plots. Looking only at the green ash, the plot survival rates ranged from 83.3 to 100 percent.

Northern red oak was planted exclusively or in a combination with other species in ten plots. Looking only at northern red oak in the ten plots, the plot survival rates ranged from 18.5 percent to 100 percent. Plot # 1 had the 18.5 percent survival rate. This plot is located next to a small dirt road that runs through the site. In 2003, erosion formed a ditch along this road and washed away 21 northern red oak seedlings from the plot.

The current average height is 3.9 feet for green ash, 4.05 feet for northern oak and 1.75 feet for silky dogwood.

There were three woody invasive species found at this site. There are 18 multiflora rose per acre, 9 bush honeysuckle (*Lonicera sp)* per acre and 2 Autumn olive per acre. Average height of the honeysuckle and multiflora rose is 4 feet while the Autumn olive is 7 feet.

Gray dogwood (*Cornus racemosa*) was found at this site at the rate of two per acre but it was very numerous in the field south of the site.

Decline/dieback was detected on 42 seedlings over the ten year span. Green ash accounted for two of this total, silky dogwood accounted for eight, while northern red oak accounted for 32. One of these green ash, three of the silky dogwoods and 8 of the northern red oaks have died. The average height of the remaining oaks that had decline/dieback was 2.3 feet while it was 4.55 feet for oaks with no decline/dieback.

Defoliation caused by the orange-striped oak worm (*Anisota senatoria*) was detected on 2 seedlings in 2006, seven in 2007, twelve in 2008 and seven in 2009. Defoliation was detected on two of these seedlings twice. None of these seedlings have shown signs of decline/dieback since the defoliation.

Site # 4 Woodbury Wildlife Area # 1

Oak (northern red and white) survival was 44.9 percent after the first five growing seasons, 96.0 percent for the last five growing seasons and now averages 43.1 percent.

The worst annual site survival rate was 66.1 percent in year # 2 (2001) and was 100 percent in year # 8 (2007) and # 9 (2008).

Plot survival ranged from 19.0-77.8 percent with 4 plots over 50 percent, 4 plots from 25 to 50 percent and 4 plots less than 25 percent. Plot #s 1-8 averaged 50.3 percent while plot #s 9-12 averaged 24.8 percent.

The site had a 100% APSR of 38.3 percent during the first five years and increased to 91.7 percent during the last five years.

Seedling height averaged 2.45 feet in 2004, 3.5 feet in 2006 and 4.6 feet in 2009. Average seedling height per plot in 2009 ranged from 2.7 to 6.8 feet.

Orange-striped oak worm defoliation was detected on 1 seedling in 2007, 28 in 2008 and 12 in 2009. Over this 3 year span 30 seedlings have been defoliated once, 4 have been defoliated twice and 1 has been defoliated three times.

Decline/dieback was detected on 76 seedlings over the ten year period, 45 of which have died. The remaining 31 seedlings have an average height of 3.15 feet compared to an average height of 5.75 feet for seedlings that had no decline/dieback. Only one of the defoliated seedlings has shown signs of decline/dieback.

Multiflora rose currently averages 9 per acre and has an average height of 5.5 feet.

Mechanical damage was noted on a total of eight seedlings in plot #s 9-12 in 2001.

Site # 5 Woodbury Wildlife Area # 2

The overall survival rate after 10 growing seasons is 84.1 percent. Green ash had a 92.8 percent survival rate for the first 5 years, 99.0 percent survival rate the last five years and now averages 91.8 percent. Northern pin oak had a first five year survival rate of 76.6 percent, 94.6 percent for the last five years and now averages 75.5 percent.

There has been a total of 17 green ash and 46 northern pin oak that died at this site. Of this total, 9 green ash and 35 northern pin oak were destroyed in 2004 for a gas well road that goes through plot #s 5 and 6 and for the gas well located in a portion of plot #s 7 and 8. The gas well road and gas well are shown in the aerial photograph of this site in Appendix A.

The lowest annual survival rate for this site was also in 2004 at 87.6 percent. The next lowest annual survival rate was 98.7 percent. The previously mentioned gas well and road greatly influenced the percentage in 2004.

Green ash plot survival ranged from 79.4-100 percent with the two lowest rates in plot #s 5 and 6. Northern pin oak plot survival ranged from 30.0 -100 percent with plot #s 7 and 8 having the two lowest rates. No seedlings have died in plot #s 1, 4 and 9.

Green ash height now averages 5.6 feet and northern pin oak now averages 11.7 feet. There is only one green ash that is 10 feet or taller while there are 102 northern pin oaks that are 10 feet or taller.

This site has the highest green ash survival and also the largest average height for both green ash and oak.

There are currently 20 multiflora rose per acre and 23 Autumn olive per acre. Average height is 5 feet and 7.5 feet respectively.

Decline/dieback has been detected on 12 green ash and 11 northern pin oak with two of each species dying. The average height of the remaining 10 green ash is 3.5 feet compared to 5.1 for green ash that had no decline/dieback while the average height of the remaining 9 northern pin oak is 8 feet compared to 12.15 feet for the northern pin oak that had no decline/dieback.

Site # 6 Egypt Valley Wildlife Area

The 10 year overall survival rate for this site is 32.8 percent which is the lowest rate of any of the reclaimed sites. The ten year survival rate for green ash of 65.1 percent which is the lowest of the five sites where green ash was planted. All 149 of the Virginia pine planted have been dead since 2006. The ten year survival rate for oaks (northern red, white and shumard) was poor at 37.6 percent while it was good for silky dogwood at 83.9 percent.

The two lowest annual site survival rates were in 2002 and 2003 at 81.8 and 69.7 percent, respectively.

All of the seedlings are dead in 5 of the 12 plots (#s 1, 3, 7, 8 and 9).

Green ash height averaged 2.55 feet in 2009, oaks averaged 3.45 feet and silky dogwood averaged 2.3 feet. This was the lowest average height for ash at any of the five sites where ash was planted.

Autumn olive is widespread at this site as there are approximately 435 per acre with an average height of 8.3 feet. Over half the seedlings have an Autumn olive growing within 5 feet and many have multiple Autumn olive growing within 5 feet. The Autumn olive can be seen in the aerial photograph of this site in Appendix A.

Decline/dieback was detected on 167 seedlings of which 82 were Virginia pine, 61 were oaks, 13 were green ash and 11 were silky dogwood. All 82 of the Virginia pine died along with 46 of the oaks and 5 green ash. None of the silky dogwoods died. Average height of the remaining seedlings was 1.8 feet for oaks, 2.1 feet for green ash and 2.45 feet for silky dogwood. Average height of the seedlings that never showed signs of decline/dieback was 4.15 feet for oaks, 3.30 feet for green ash and 2.35 feet for silky dogwood.

Rabbit damage occurred on 36 seedlings in 2000 and on 1 seedling in 2001. All but 1 of the 37 seedlings have died.

Site # 7 – High Hill

Austrian pine was the only species planted at this site and had a 5 year survival rate of 55.8 percent, a 95.2 percent survival rate for the last 5 years and now averages 53.2 percent.

The lowest annual survival rate was 82.5 percent in 2000 and was 99.5 percent or greater in each of the last five years.

Plot survival rates ranged from 25.9-72.4 percent with seven of the plots between 50-59.9 percent. Four of the six pairs of plots had less than a 10 percent difference in survival rates.

In the first five growing seasons 15 percent of the plots had a 100% APSR while during the last 5 growing seasons 95 percent of the plots had a 100% APSR.

The average height of the seedlings in 2009 was 6.25 feet. Seedlings on the eastern side of the site were much larger than the western side as plot #s 1-6 averaged 7.4 feet while plot #s 7-12 averaged 5.05 feet.

It was interesting to note that plot #2 had the lowest survival rate but had the highest average height (was tied with plot # 5) while plot # 8 had the highest survival rate but had the third lowest average height.

No invasive species were found in any of the competing vegetation plots.

Decline/dieback was detected on 40 seedlings over the ten year period of which 27 have died. The average height of the remaining 13 trees is 3.0 feet compared to 6.48 for the trees that showed no decline/dieback.

Site # 8 – Kilmer

The overall survival rate of this un-reclaimed site is 19.3 percent, which is the lowest of all the sites. The ten year survival rate for black locust was 0 percent, northern red oak was 13.6 percent and Virginia pine was 25.6 percent. However, the annual survival rate for this site has been 96.2 percent or greater for each of the last five years. The lowest annual survival rate was 45.2 percent in 2000.

There are no surviving seedlings in plot #s 10 and 12.

The overall average height of the seedlings at this site is 10.15 feet, which is the largest of any site. The average height of the Virginia pine is now 10.5 feet. The average height of the northern red oak actually declined from 2.75 feet in 2006 to 2.35 feet in 2009. A Virginia pine with a height of 20 feet is the largest tree at this or any site. As previously mentioned, some of the seedlings at this site may be a year or two older than the seedlings at the rest of the sites. These older seedlings may or may not be in the plots.

There was evidence (tracks, bent wire flags, missing or destroyed seedlings) of heavy ATV use at this site especially during the first couple of years of this project. Although not monitored, seedling survival was much greater on the steeper slopes than the flatter areas. However, all of the plots were located on the flatter areas.

Beavers damaged (cut down) 5 Virginia pine in 2005, ten in both 2006 and 2007 and one in 2008. Eight of the 26 Virginia pine have since died. For the most part, a Virginia pine that was cut off above some of the living branches survived but died if it was cut off below all the living branches.

There were no invasive species detected at this site.

Decline/dieback has been detected on 68 Virginia pine and 3 northern red oak of which 47 Virginia pine and 2 northern red oak have died. Average height of the remaining 21 Virginia pine is 8.1 feet compared to an average height of 11.5 feet for Virginia pine that never had any decline/dieback.

The survival rate and average height of green ash and oaks were compared by site to see if there is a correlation between good survival and good growth. This comparison was done only for green ash and the oaks since they comprise the majority of the seedlings and were planted on most of the sites. The survival and height data is summarized in the table below. Site survival and average site height were ranked for both species with # 1 being the largest, # 2 being the next largest... #5 being the smallest for green ash and # 7 the smallest for oak species. Green ash was planted on 5 sites while oaks were planted on seven sites. The erosion ditch at Site # 3 plot # 1, gas well road at Site # 5 plot #s 5 and 6 and gas well at Site # 5 plot #s 7 and 8 were one time events that significantly changed the survival rate of oaks at Site # 3 and both green ash and oaks at Site # 5. Combined, they destroyed 65 healthy seedlings. Based on the survival rates of other seedlings at those two sites, the vast majority would still be alive at the end of 10 years. To get a more representative species survival rate at each of the two sites, 21 oaks were subtracted from the number of oaks planted at site # 3, 9 green ash and 35 oaks were subtracted from the number planted at Site #5 (these were the number of seedlings destroyed). Therefore, the oak survival rate changed from 67.1 to 74.4 percent at Site # 3 and from 75.1 to 94.5 percent at Site # 5 while green ash survival rate changed from 91.8 to 96.0 percent at Site # 5.

Survival vs. height for green ash and oaks

Site #	Green ash				Oaks			
	Survival rate	Survival rank	Average height	Height rank	Survival rate	Survival rank	Average height	Height rank
1	86.6	3	2.6	4	12.3	7	1.4	7
2	86.4	4	3.45	3	88.9	2	8.5	2
3	92.0	2	3.9	2	74.4	3	4.05	4
4	n/a	n/a	n/a	n/a	43.1	4	4.6	3
5	96.0	1	5.1	1	94.5	1	11.7	1
6	65.1	5	2.55	5	37.6	5	3.48	5
8	n/a	n/a	n/a	n/a	13.6	6	2.35	6

Species survival rankings and height rankings are almost identical. Rankings are different for green ash at two sites, and there the rankings only differ by one. Likewise rankings for oak species are different at two sites, both differing in ranking by one. Based on height versus survival comparisons, a site that has good survival for a species will also have good height growth and conversely, a site that has poor survival for a species will also have poor height growth.

Seedling survival numbers were grouped by slope and aspect categories to determine if there are differences in survival rates between categories and, if there are differences, which categories favor seedling survival. Plot data from the seven reclaimed sites (#s 1-7) was used but the data from the un-reclaimed Site #8 was not used since the growing condition at this site are much different than the other seven sites. The survival rate by slope and aspect categories are presented in the table that follows.

Seedling survival by slope and aspect

Slope	Aspect	# of plots	# of seedlings planted	# seedlings surviving	Survival rate
0-2%	All	10	302	163	54.0
3-10%	N	22	639	543	84.9
3-10%	E	6	199	110	55.3
3-10%	S	22	650	262	40.3
3-10%	W	4	125	109	87.2
11-25%	N	6	144	113	78.4
11-25%	E	4	88	59	67.0
11-25%	S	6	173	90	52.0
11-25%	W	4	86	51	59.3

Since there were only 10 plots in the 0-2 percent slope categories, all the plots were grouped together regardless of aspect. For the erosion ditch plot (Site # 3 plot # 1) gas well road plots (Site # 5 plot #s 5 and 6) and gas well plots (Site #5 plot #s 7 and 8), the adjusted seedling numbers were used. So instead of using the number of 28 seedlings planted in plot # 1 at Site #3 with a survival of 6, the numbers used in this comparison is 7 seedlings planted with six surviving. The numbers in the other four mentioned plots were changed in the same fashion.

The 3-10 percent west category had the highest survival rate at 87.2 percent followed by the 3-10 percent north category at 84.9 percent and the 11-25 percent north category at 78.4 percent. The category with the lowest survival rate was the 3-10 percent south category at 40.3 percent with the next lowest being the 11-25 percent south category at 52.0 percent. However, only three of the categories had ten or more plots in them so it is difficult to get a real accurate estimate on the seedling survival potential of many of the slope/aspect categories. Looking at the 0-2 % slope/all aspect category, there was a total of ten plots. One was an oak plot at Site # 1 where oak survival was poor regardless of slope or aspect. Two additional plots where Virginia pine plots at Site # 6 where all the Virginia pine died regardless of slope or aspect. Dropping these three plots from this category would increase the survival rate from 54.0 percent to 73.3 percent. With so few plots, a couple of poor survival plots can significantly alter the survival rates of a category.

For reforestation purposes throughout the US, the number of seedlings planted per acre commonly ranges from 435 to 726 and averages 500 per acre. The number of seedlings planted at these eight abandoned mine lands sites ranged from 399 to 1569 per acre and averaged 656 per acre. The table that follows presents the number of seedlings planted per acre and the number of seedlings surviving after 10 growing seasons for each of the eight sites. The overall number of seedlings per acre has decreased from 656 per acre to 310 per acre, a 52.8 percent reduction. Looking at only the seven reclaimed sites, the number of trees per acre has been reduced by 41.0 percent. Current seedlings per acre range from a low of 180 per acre (Site #4) to a high of 411 per acre (Site # 3). Fortunately the site that had the lowest survival rate (Site #8) had the largest number of seedlings planted per acre. Even though there has been a reduction in seedlings by 80.7 percent at that site, there are still 303 seedlings per acre.

Number of seedlings planted per acre and number of surviving seedlings after 10 growing seasons.

Site #	Seedlings per acre		Percent Survival
	Planted in Spring 2000	Surviving Fall 2009	
1	558	298	53.4
2	414	366	88.4
3	651	471	72.4
4	418	180	43.1
5	399	335	84.1
6	662	217	32.8
7	574	305	53.2
8	1569	303	19.3
1-8 (Average)	656	310	47.2
1-7 Average)	525	310	59.0

DISSCUSSION

Overall seedling survival was much greater on the seven reclaimed sites than on the un-reclaimed Site #8 (61.0% vs. 19.3%). This was not surprising due to the poor growing conditions encountered at the un-reclaimed site (no topsoil, higher soil temperatures during growing season, less soil moisture during growing season). Another major factor that greatly influenced seedling survival at this site was heavy ATV usage which killed a lot of seedlings when they were run over and/or through soil compaction. The vast majority of the time the plots were visited during the first five growing seasons, the flags were bent over at ground level which was further proof of ATV usage at the plots. All of the plots were on a fairly level bench located between a vertical high-wall and a steep fill slope and is where most of the ATV usage occurred. Based on observations (no plot data), seedling survival and height was much greater on these steep fill slopes then the fairly level areas. Due to the steepness of the slopes, ATV usage in these areas was minimal to non-existent.

Seedling survival was poor at Site # 6 as the overall average for all the species combined is 32.8 percent. Of all the reclaimed sites, green ash survival was the lowest at this site while oak survival was the next to lowest at this site. Virginia pine survival at this site was zero. The likely cause for poor seedling survival at this site is Autumn olive. This undesirable invasive species is highly aggressive and has taken over several of the plots and covers at least 75 percent of this site with its dense foliage. There are now approximately 435 Autumn olive per acre with many of these ranging in height from 10-15 feet. Average height of the Autumn olive is 8.3 feet compared to the average seedling height of 2.95 feet. There are now only 217 seedlings surviving per acre. When the plots were established at this site, there were several "brush hogged" Autumn olive at this site. It is likely that the current infestation is comprised by re-sprouting of the Autumn olive stumps and from seed produced from Autumn olive before they were "brush hogged". The site is a prime example of what Autumn olive or other invasive species can do to seedling survival. Invasive species were found at 5 additional sites. Intervention tactics should be implemented before they have significant impact on the seedlings at these sites.

It is likely that the average height of Autumn olive given for Site #6 (8.3 feet) is over estimated a little but since only the largest specimen of a species was measured at each competing vegetation monitoring plot. If there was an Autumn olive with a height of 6 feet and a smaller one, only the largest one was measured but both were counted for the number for that plot and the number per acre.

There were many plots that contained multiple Autumn olive at the site. On the other hand, the number of Autumn olive per acre at this site was probably under estimated. Five of the twelve seedling plots have no living seedlings so they were not monitored for invasive species. It is very likely that Autumn olive was a major factor of the 100% mortality of these five plots. If a competing vegetation plot was established where a seedling was planted, instead of only where there was a living seedling, the number of Autumn olive would be even more than 435 per acre instead. During the next monitoring visit in 2014, competing vegetation plots will be established at the same locations as they were during the last visit in 2009.

The other biggest threat to the overall success of the reforestation program on abandoned mine land is the emerald ash borer (*Agrilus planipennis*). This exotic beetle from Asia feeds only of the foliage of ash species as adults while the larval feed in the phloem and outer sapwood of ash species. An infested ash usually dies within 3-5 years. This destructive pest was first found in Ohio in 2003 and has now been detected in 48 counties. Currently infested counties are shown in Figure 2. Emerald ash borer (EAB) has already destroyed thousands of ash trees in Ohio. Due to the high ash component at Site #s 1, 2, 3, 4 and 6, EAB could kill approximately one third of the seedlings at these sites over the next ten years. There currently are no large scale control measures for this destructive insect.

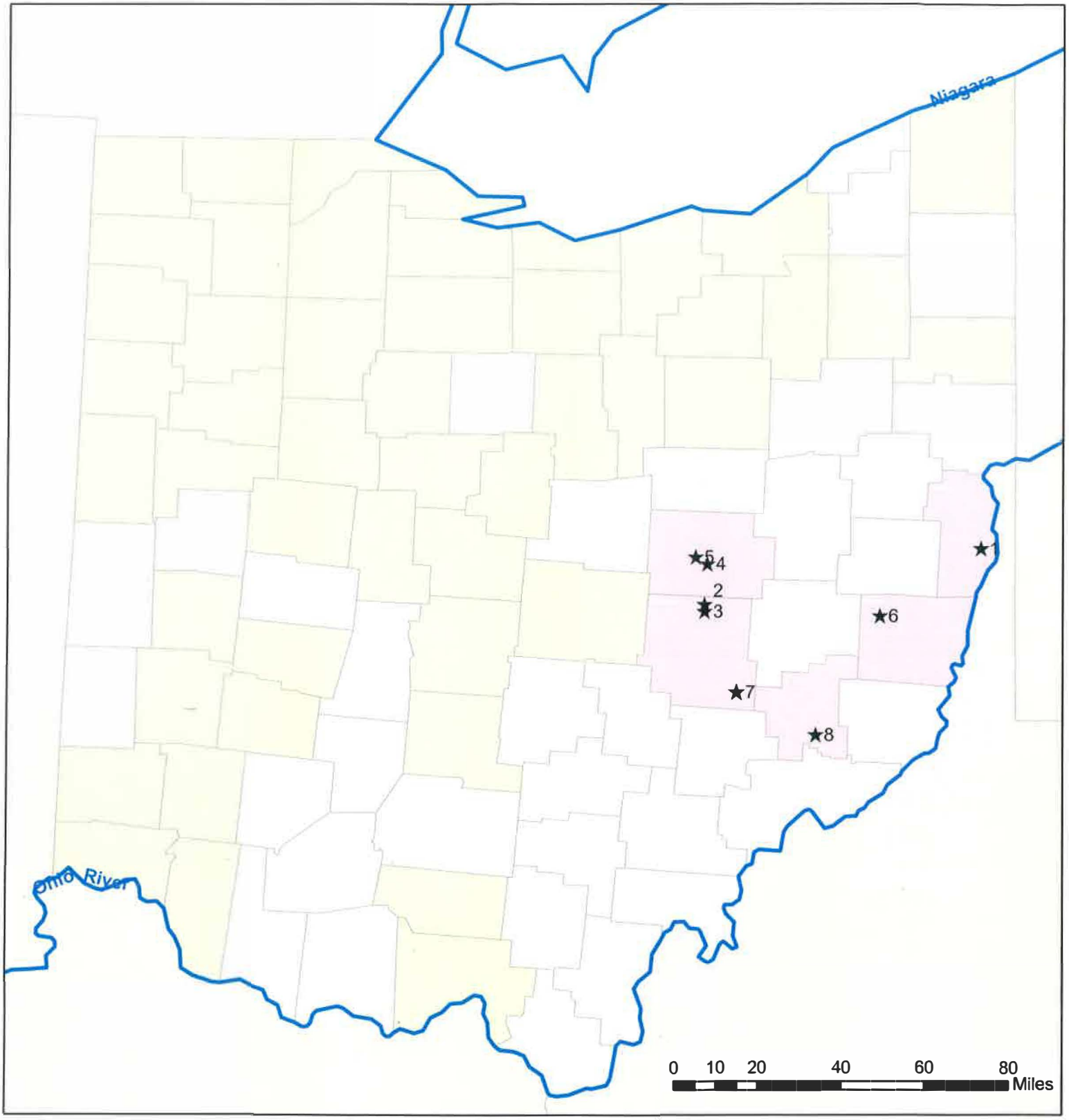
It was expected that seedlings mortality would be the highest during the first couple of growing seasons and then taper off annually to a minimal amount. The overall survival rate was the worst during the first growing season with the next worst during the second year. The overall annual survival rate has exceeded 98 percent in each of the last five growing seasons. Most of the sites experienced fairly significant mortality the first five years and fairly minimal mortality the last five years. Likewise, mortality on green ash and oak species follow the same pattern as mortality was fairly significant during the first five years and fairly minimal the last five years. Without the presence of invasive species and the emerald ash borer, it is expected that mortality will be minimal over the next five years.

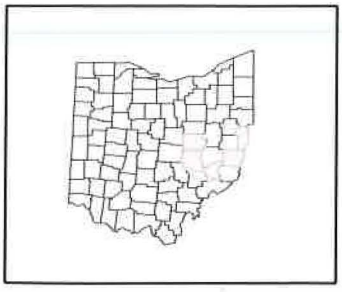
There are five sites (Site #s 1, 2, 3, 5 and 6) where both green ash and oak species were planted. Green ash survival exceeded oak survival at all these sites except at Site # 2 where oak survival was 2.5 percent more than green ash survival. At Site #s 3, 5, and 6, green ash survival exceeded oak survival by 15-25 percent. The largest difference in survival between these species occurred at Site #1 where green ash survival was 86.6% and oak species averaged only 12.3%. This large difference in survival rates and the low survival rate for oak was probably caused by the soil pH. This site has an alkaline soil pH which favors green ash survival over oaks, which prefer an acidic soil pH. While it looks like green ash will survive better than oaks in most sites, these differences will be greater on sites with an alkaline soil pH. For the most part, sites that had good green ash survival also had good oak survival while sites that had poor ash survival also had poor oak survival.

Although green ash had higher survival rates than oaks on four of the five sites while both were grown, oaks had larger average heights at four of the five sites. Site # 1 was the only site where green ash height exceeded oak height. Oak height was more than double that of ash height at Site # 2 and # 5. For the most part, average oak height will exceed average ash height.

At a given site, the annual survival rate for a species, annual survival rates per plot and 10 years survival rates were fairly uniform. Although not all the major differences can be explained, some have

Figure 2. -- Location of EAB infested counties in relation to the eight seedling sites.





★ Study Areas
Major rivers
EAB Counties
Study Counties
Ohio
West Virginia

N
W E
S

USDA Forest Service 3/10

simple explanations. Previously mentioned erosion ditches, gas well and gas well road can cause significant changes to annual survival rates (northern red oak at Site #3 during the fourth growing season, and green ash and northern pin oak at Site #5 during the fifth growing season) and plot survival rates (Site #3 plot #1 and Site #5 plots #5, #6, #7 and #8). Without these three things, there would have been even more uniformity in both the annual survival rate for a species at a site, annual plot survival rates and the 10 year survival rates for a species at a site. However, there are some differences in the rates that can not be explained. For instance at Site #7, plot #s 1 and 2 are adjacent to each other with both having the same species, slope and aspect. The ten year survival rate for plot #1 is 69 percent while it is 25.9 percent for plot # 2.

Slope and aspect play a significant role in seedling development. As a general rule, northwestern, northern and northeastern aspects will have higher survival rates than the other aspects and gentle slopes will have better survival than steeper slopes. Steep slopes with southeastern, southern and southwestern exposures will usually have low soil moisture during the growing season which adversely affects both seedling survival and growth. Based on our plot data, the northern and western aspect with 3-10% slopes had the highest annual survival rates while the southern aspect with 3-10% and 11-25% slopes had the worst survival rates. However, only three of the slope/aspect categories had 10 or more plots and each slope/aspect category was not uniformly distributed at every site. There were some sites that oak did poorly (Site # 1) or all species did poorly (Site # 6). Having a high number of these plots in any slope/aspect category significantly reduces the overall survival rate of that particular category. As previously stated, adequate numbers of seedling and plots are needed in a slope/aspect category in order to get an accurate estimate on seedling survival.

Aspect undoubtedly played a large role in the difference in seedling survival and height between Site #s 4 and 5. Even though the sites are separated only by a couple of miles, oak survival was 75.5 percent at Site # 5 and 43.1 percent at Site # 4. The oak survival at Site # 5 would be 94.6 percent if adjusted for the 35 oak seedling destroyed for the gas well and road. Average height of the oak seedlings at Site # 4 was 4.65 feet while it was 11.85 feet at Site # 5. Using the "adjusted" survival rate, Site # 5 had more than double the oak survival rate and average height than Site # 4. The most obvious difference in site conditions between these two site is aspect. Most of the plots at Site # 4 have a southern exposure while most of the plots at Site # 5 have a northern exposure.

Site # 1 (Fernwood State Forest) is the only site where native regeneration was detected in any significant amount. At this site, there are several fairly thick black locust "islands" scattered about that are spreading in adjacent areas. Currently there are approximately 243 black locust trees per acre. Black locust is in the legume family and fixes atmospheric soil nitrogen into soil nitrates that are used by other plants. This is probably the reason why seedlings growing near black locust were, on average, taller than seedlings that were not growing near black locust. However, black locust has rapid growth as a juvenile and may eventually out-compete and suppress the planted seedlings.

Due to the abundance of deer in the study area, it was thought that they would have a significant impact on seedling survival. Over the ten year period, deer have had virtually zero impact on the seedlings. Only a couple of seedlings showed signs of feeding damage caused by deer. In the last five years, only one seedling was damaged by deer and that damage was caused by a buck rubbing his horns on the seedling. The lack of damage caused by deer might have been caused by the distance that the seedlings were planted away from wooded areas. Most of the seedlings were planted in large

grassy areas at least a hundred yards away from wooded areas. Deer damage likely would have been much higher if the areas planted were adjacent, or at least closer, to wooded areas. The animal that caused the most damage to the seedlings were rabbits. At Site # 2, rabbits damaged approximately 75 percent of the green ash seedlings and 5 percent of the oak seedlings during the first couple of years. Only a couple of these seedlings have died and rabbit damage has been very minimal over the last eight years. Rabbits also damaged a fair number of seedlings at Site # 6. It was interesting to note that most of these seedlings died while, as previously mentioned, the rabbit damaged seedlings at Site #2 had a very high survival rate. However, the seedling survival rate at Site # 6 was poor, regardless if they had been damaged by rabbits or not. Beavers are the other animal that have damaged some seedlings. Their damage was limited to Site # 8. All of the seedlings that were damaged were located less than 75 feet from water. Impact on seedlings that are not close to water was non-existent.

As previously stated, a significant amount of rabbit damage occurred at Site # 2 during the first year. Even though Site # 3 was located only a couple miles away from Site # 2, no seedling damage caused by rabbits was detected at this site. A major difference between these two sites is the amount of rubus present. At Site #2, there is a fair amount of rubus while at Site #3 there is very little. The rubus at Site #2 may provide enough cover and protection from predators that the rabbit population is high and thus damage to the seedlings is significant. While at Site #3, the lack of cover and protection is low and thus the rabbit population and rabbit damage to seedlings was also low. As the seedlings grew at Site # 2, (or any other site) they seem to become less attractive to rabbits as rabbit damaged seedlings were minimal the second year and were non-existent after that.

There is a positive correlation between seedling survival and seedling height for a species. Sites where survival is good for a species also had good height growth for that species while sites that had poor survival for a species also had poor height growth for that species. Site # 5 had the highest survival rate and average height for green ash while Site # 6 had both the lowest survival rate and average height for green ash. Site # 6 had both the highest survival rate (adjusted for gas well and road) and height for oaks while Site # 1 had the lowest survival rate and average height for oaks. For the most part, a site that was a good green ash site was also a good oak site while a site that is poor for green ash is also poor for oaks. Site # 5 had both a good survival rate and height growth for both green ash and oaks while Site # 6 had poor survival rates and growth for both green ash and oaks.

Mechanical damage to seedlings was the highest at Site # 8 and is one of the reasons why this site has a low survival rate. The heavy ATV usage at this site eliminated a lot of the seedlings. However, these seedlings were killed and removed from the plots so they were classified as either dead or missing so it is difficult to get an accurate number of mechanically damaged seedlings at this site. Forty four seedlings were killed by a bulldozer at Site # 5 during the fifth growing season for the gas well and road. Mechanical damage was detected on a handful of seedlings at Site # 4 plot #s 9-12 during the first couple of growing seasons. These plots are located adjacent to a small road that runs through the site. No mechanical damage has been detected over the last five years.

Approximately 56 percent of the seedling that shows signs of decline/dieback have died. Pines that show signs of decline/dieback are more likely to die (65% vs. 47%) than hardwoods that show signs of decline/dieback. Mortality rates on these decline/dieback seedlings were higher at sites with a high number of decline/dieback seedlings and lower at sites with fewer of these seedlings. The severity of decline/dieback on seedlings was likely greater at sites that had a large number of these seedlings,

which would result in a higher mortality rate at these sites. The height of seedlings that showed signs of decline/dieback over the ten year period is approximately a third less than seedlings with no decline/dieback history.

The only insect that has caused any noticeable damage to the seedlings is the orange-striped oak worm. Form 2006-2009, this insect has caused defoliation on 62 oak seedlings at two of the sites. All of these seedlings are still living and only one has shown signs of decline/dieback. Unlike gypsy moth that is a Spring/ early Summer defoliator, the orange-striped oak worm is a late Summer defoliator that starts feeding on foliage around mid-August. Defoliation this late in the growing season is a lot less harmful to the health of a seedling or a tree. It is not expected that orange-striped oak worm will have any significant impacts on the oaks in this study.

The number of seedlings per acre has decreased to an overall average of 310 per acre with individual sites ranging from a low 180 per acre to a high of 471 per acre. As expected, the largest reduction (both percentage and number) occurred at Site #8. In order for a site to receive the maximum benefits of this reforestation program, there must be enough trees per acre to fully occupy the site. As the seedlings grow into trees, less are needed to fully occupy a site. Based on the current number of seedlings per acre and survival rates at these eight sites, it is likely that over half of the sites will not have enough trees to be fully occupied. Even on sites that are not fully occupied, the trees will still be beneficial.

SUMMARY

Listed below is a very brief summary of the seedling survival study on abandoned mine-lands in eastern Ohio.

- Green ash survival will exceed oak survival but the oaks will be taller than green ash.
- Survival will be less on un-reclaimed (gob pile) sites than reclaimed (grassland) sites.
- Northern aspects will have better survival then southern aspects.
- Oaks planted in soil with an alkaline pH will have less survival than oaks planted in soils with an acidic pH.
- Rabbit damage may be significant the first couple of years but will decrease over time.
- Sites where survival is good will have good height growth while sites where survival is poor will have poor height growth.
- ATVs are hazardous to seedling survival.
- Invasive species are hazardous to seedling survival. Invasive species have already had significant impact at one site. Unless intervention tactics are implemented, they will likely have significant impacts at other sites.
- Seedlings that show signs of decline/dieback are likely to die, especially pines. Seedlings with decline/dieback that do survive will be smaller than other seedlings.
- Mortality will be much greater the first five growing seasons than the next 5 years growing seasons.
- EAB is getting close to the sites. The impact to ash at these sites could be significant over the next 5 years
- The height growth of the seedlings is increasing at an accelerated pace.

CONCLUSION

Results of this study should be used to improve the overall success of this reforestation program on abandoned mine-lands in eastern Ohio. Site characteristics and seedling species requirements need to be evaluated prior to planting in order to have a better chance of the planted seedlings surviving and fully occupying a site when they mature. In areas where mortality is likely to be high, more seedlings will need to be planted to insure there is an adequate number of trees in the future. Regardless of the type of reclamation, abandoned mine-lands do not favor optimal seedling survivability and growth. However, abandoned mine lands can be successfully reforested and the adverse impacts of these areas can be reduced or eliminated.

APPENDIX A

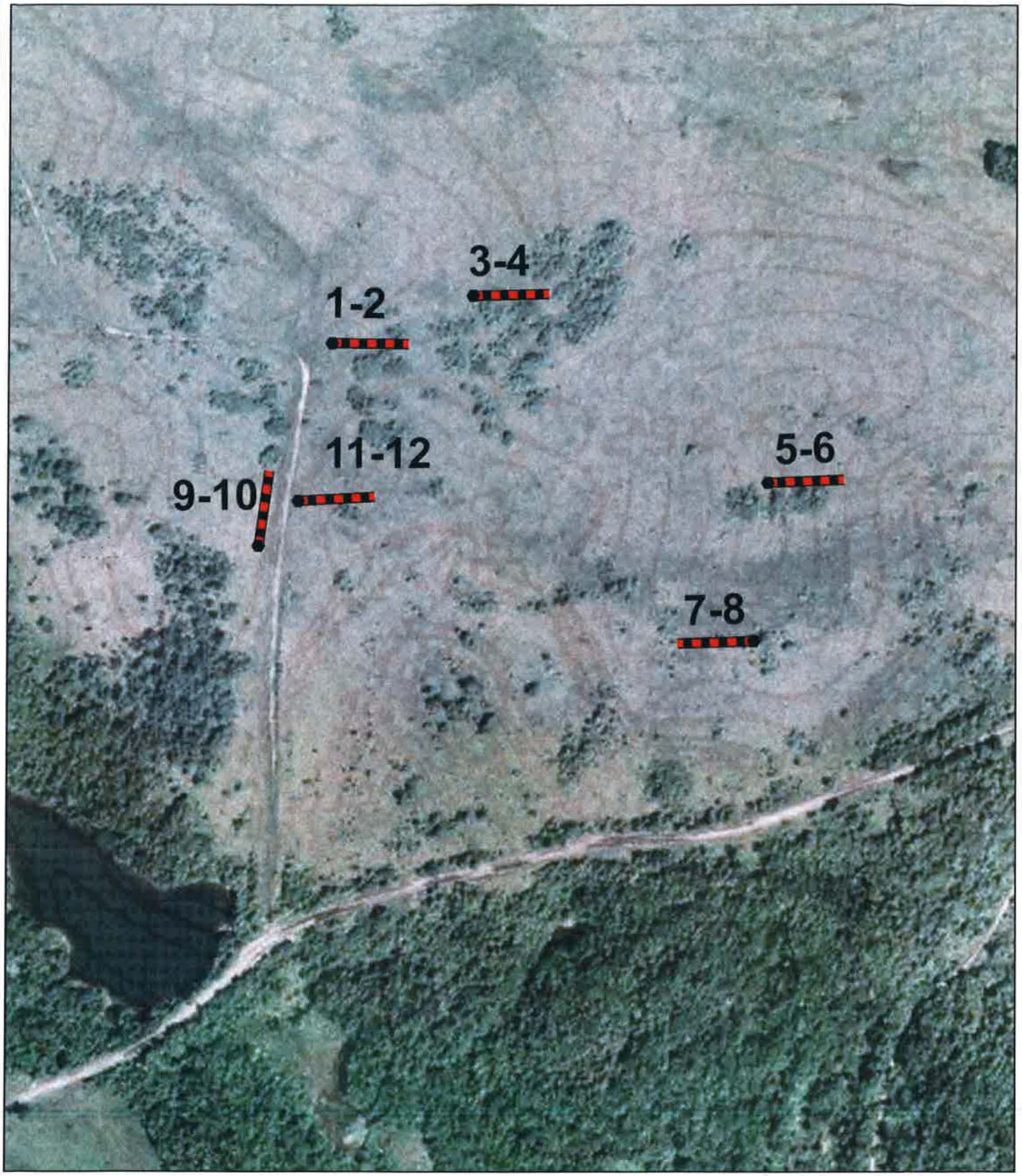
Location of individual plots at each site,

Slope, aspect and directions for individual plots at each site

and

General comments

Plot locations at Fernwood State Forest (site #1)



USDA, FS, NA, FHP
MFO, kf 03/18/10

0.1 0.05 0 0.1 Miles

Legend

Plot locations

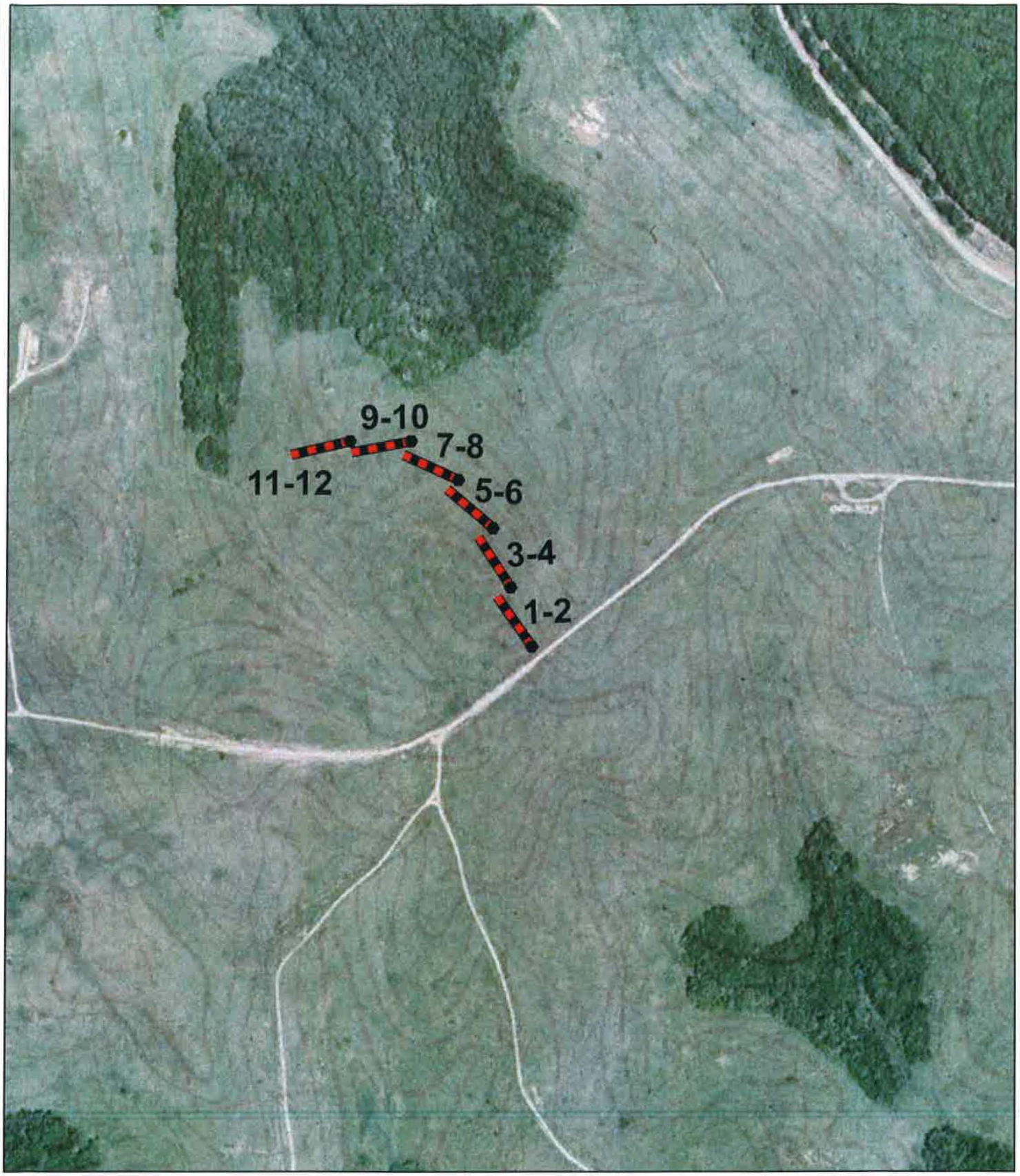
Slope, aspect and directions for each plot at Fernwood State Forest (Site # 1)

Plot #	Slope	Aspect	Directions
1	0-2%	10°	85 feet at 70° from turn in road
2	0-2%	10°	adjacent to plot # 1, but 1 row to the north
3	3-10%	0°	195 feet for 62° from end of plot # 2
4	3-10%	0°	adjacent to plot #3, but 1 row to the north
5	11-24%	350°	750 feet for 134° from end of plot # 4
6	11-24%	350°	adjacent to plot # 5, but 1 row to the north
7	11-24%	170°	450 feet for 210° from end of plot # 6
8	11-24%	170°	adjacent to plot # 7, but 1 row to the south
9	3-10%	80°	250 feet before turn in road, then 40 feet for 270°
10	3-10%	80°	adjacent to plot # 9, but 1 row to the west
11	11-24%	250°	300 feet before turn in road, then 30 feet for 90°
12	11-24%	250°	adjacent to plot # 11, but 1 row to the north

General comments

There are six pairs of plots at this site. Each pair is spaced 150-750 feet from the next pair. Each pair is composed by an ash plot and an oak plot.

Plot locations at TriValley Wildlife Area #1(site #2)



USDA, FS, NA, FHP
MFO, kf 03/18/10

0.1 0.05 0 0.1 Miles

Legend

Plot locations

Slope, aspect and directions for each plot at Tri Valley Wildlife Area # 1 (Site # 2)

Plot #	Slope	Aspect	Directions
1	0-2%	20°	600 feet past gate, then 10 feet at 300°
2	0-2%	20°	adjacent to plot # 1 but 1 row lower
3	3-10%	15°	end of plot # 2, then 1 row lower
4	3- 10%	15°	adjacent to plot #3 but 1 row lower
5	3-10%	30°	end of plot # 4, then 1 row lower
6	3-10%	30°	adjacent to plot # 5 but 1 row lower
7	11-25%	25°	end of plot # 6 , then 1 row lower
8	11-25%	25°	adjacent to plot # 7 but 1 row lower
9	11-25%	340°	end of plot # 8, then 1 row lower
10	11-25%	340°	adjacent to plot # 9, but 1 row lower
11	11-25%	310°	end of plot # 10 , then 1 row lower
12	11-25%	310°	adjacent to plot # 11 but 1 row lower

General comments

There are six pairs of plots at this site. Each pair of plot starts near the end of the proceeding pair but one row lower. The first two pairs had both an oak plot and an ash plot while the last four pairs were comprised by oaks. There was a lot of rubis at this site and several of the ash seedlings were already damaged by rabbits. Larger oak seedlings were planted in rows #s 10, 11 and 12.

Plot locations at TriValley Wildlife Area #2 (site #3)

USDA, FS, NA, FHP
MFO, kf 03/18/10

0.1 0.05 0 0.1 Miles

Legend

Plot locations

Slope, aspect and directions for each plot at Tri Valley Wildlife Area # 2 (Site # 3)

Plot #	Slope	Aspect	Directions
1	11-25%	105°	30 feet past dip in road through field, plot is 5 feet on left side of road
2	11-25%	105°	adjacent to plot # 1, 1 row to the left (SW)
3	11-25%	105°	adjacent to plot # 2, 1 row to the left
4	11-25%	105°	adjacent to plot # 3, 1 row to the left
5	3-10%	40°	100 feet past end of plot # 4
6	3-10%	40°	adjacent to plot # 5, 1 row to the left
7	3-10%	40°	adjacent to plot # 6, 1 row to the left
8	3-10%	40°	adjacent to plot # 7, 1 row to the left
9	3-10%	10°	end of plot # 8, 1 row to the left
10	3-10%	10°	adjacent to plot # 9, 1 row to the left
11	3-10%	10°	adjacent to plot # 10, 1 row to the left
12	3-10%	10°	adjacent to plot # 11, 1 row to the left

General comments

This site is comprised by three sets of four plots. Plot #s 1-4 are adjacent plots, #s 5-8 are adjacent plots as well as
#s 9-12. NRO comprises plot #s 1, 2, 3, 9, 10 and 12, a combination of NRO and GA comprises plot #s 6, 7, 8 and11 while a combination of GA and SDW comprises plot #s 4 and 5

Plot locations at Woodbury Wildlife Area #1 (site #4)

N
W E
S

0.1 0.05 0 0.1 Miles

Legend

Plot locations

USDA, FS, NA, FHP
MFO, kf 03/18/10

Slope, aspect and directions for each plot at Woodbury Wildlife Area # 1 (Site # 4)

Plot #	Slope	Aspect	Directions
1	11-25%	150°	63 feet at 63° from dip in road through field, near large pond
2	3-10%	210°	from end of plot # 1, 1 row higher
3	3-10%	210°	from end of plot # 2, 1 row higher and back 27 feet
4	3-10%	205°	from end of plot # 3, 1 row higher
5	3-10%	190°	from end of plot # 4, 1 row higher
6	11-25%	170°	from end of plot # 5, 1 row higher and back 14 feet
7	11-25%	175°	from end of plot # 6, 1 row higher
8	11-25%	175°	from end of plot # 7, 1 row higher
9	3-10%	225°	50 feet for 58° from dip in road through field
10	3-10%	225°	adjacent to plot # 9, 1 row to the left
11	3-10%	260°	from end of plot # 10, 1 row to the left then back 40 feet
12	3-10%	260°	adjacent to plot # 11, 1 row to the left

General comments

NRO makes up 10 plots while a combination of NRO and WO comprises the other 2 plots. The first 8 plots are single plots with the next plot starting near the end of the proceeding plot but one row higher. Plot #s 9 and 10 are a pair of plots as well as #s 11 and 12.

Plot locations at Woodbury Wildlife Area #2 (site #5)

USDA, FS, NA, FHP
MFO, kf 03/18/10

Slope, aspect and directions for each plot at Woodbury Wildlife Area #2 (Site 5)

Plot #	Slope	Aspect	Directions
1	3-10%	310°	337 feet at 42° from large dirt mound
2	3-10%	310°	adjacent to plot # 1, 1 row to the north
3	3-10%	320°	200 feet past end of plot # 1
4	3-10%	320°	adjacent to plot # 3, 1 row to the north
5	3-10%	320°	200 feet past end of plot # 3
6	3-10%	320°	adjacent to plot # 5, 1 row to the north
7	3-10%	320°	125 feet at 330° from end of plot # 6
8	3-10%	320°	adjacent to plot # 7, 1 row to the north
9	3-10%	320°	200 feet past end of plot # 7
10	3-10%	320°	adjacent to plot # 9, 1 row to the north
11	3-10%	320°	100 feet past end of plot # 9
12	3-10%	320°	adjacent to plot # 11, 1 row to the north

General comments

There are 6 pair of plots at the site spaced 100 - 200 feet from the next pair. GA comprises the first 3 pairs while NPO comprises the last 3 pairs.

Plot locations at Egypt Valley Wildlife Area (site #6)

All seedlings in plot # 1,3,7,8,and 9 have been dead for several years. These plots have been abandoned.

N
W E
S

0.1 0.05 0 0.1 Miles

USDA, FS, NA, FHP
MFO, kf 03/18/10

Legend

Plot locations

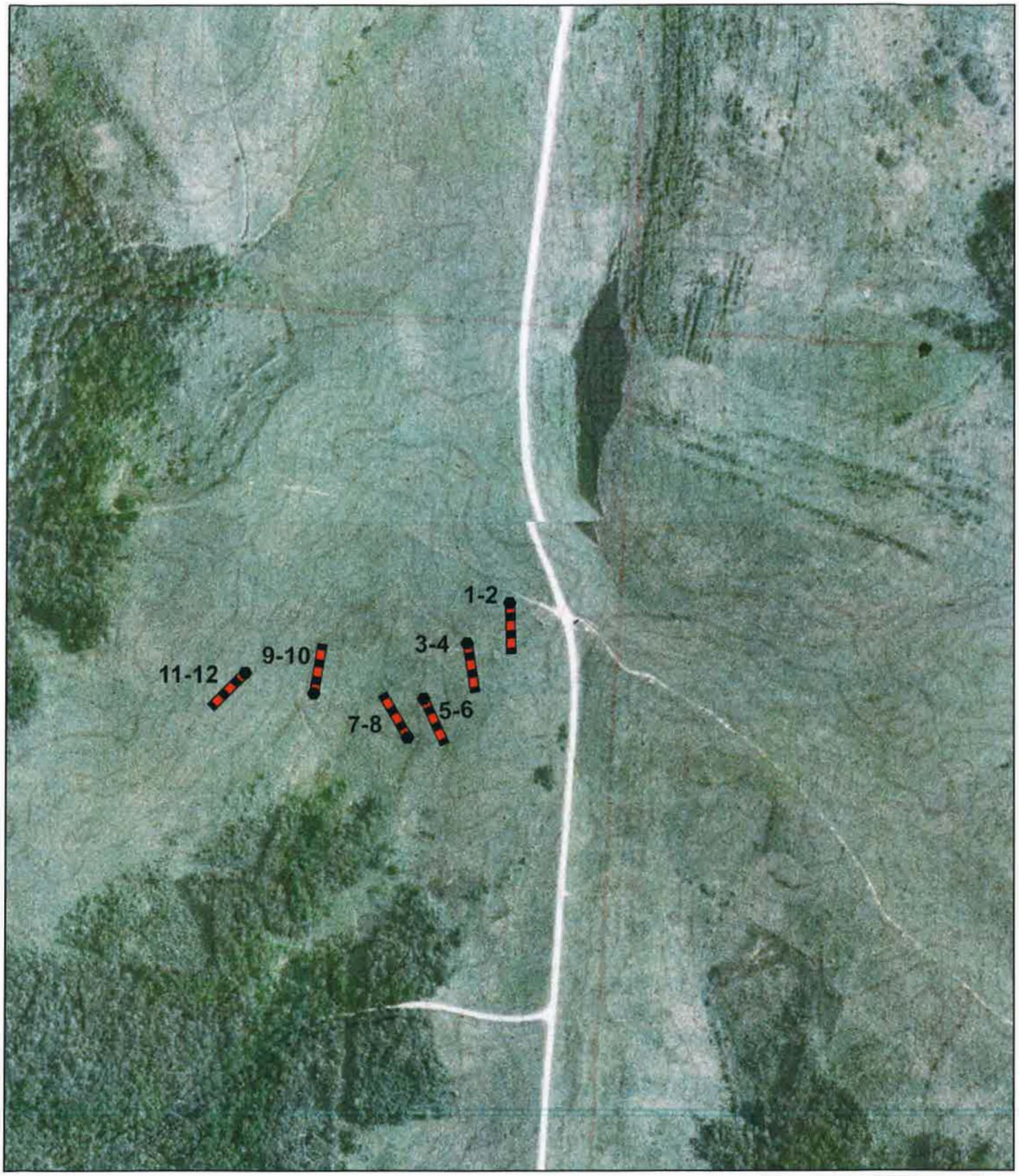
Slope, aspect and directions for each plot at Egypt Valley Wildlife Area # 1 (Site #6)

Plot #	Slope	Aspect	Directions
1	3-10%	160°	from pull-off on west side of road, take grass road to field, plot will be on left 20 feet from the field edge
2	3-10%	160°	adjacent to plot # 1 , 1 row to the right
3	3-10%	160°	76 feet at 272° from start of plot # 2
4	3-10%	155°	50 feet at 286° from start of plot # 3
5	3-10%	155°	adjacent to plot # 4, 1 row to the right
6	3-10%	155°	adjacent to plot # 5, 1 row to the right
7	0-2%	90°	from pull-off on east side of road, 150 feet at 40°
8	0-2%	90°	adjacent to plot # 7, 1 row to the right
9	3-10%	60°	from pull-off on east side of road, 40 feet at 360°
10	3-10%	60°	adjacent to plot # 9, 1 row to the left
11	0-2%	130°	250 feet west on secondary road, plot on right side 25 feet off road
12	0-2%	130°	adjacent to plot # 11, 1 row to the left

General comments

The plots at this site are located in three separate areas. Plot #s 1-6 are in one area, #s 7-10 are in another area while #s 11 and 12 are in the last area. VP comprises plot #s 1, 7 and 8, oaks comprise #s 9, 11 and 12 while a mixture of species comprise #s 2, 3, 4, 5 and 6. There are several "brushed hogged" Autumn olive at this site.

Plot locations at High Hill (site #7)



USDA, FS, NA, FHP
MFO, kf 03/18/10

Slope, aspect and directions for each plot at High Hill (Site # 7)

Plot #	Slope	Aspect	Directions
1	0-2%	55°	304° for 150 feet from well tanks
2	0-2%	55°	adjacent to plot # 1, 1 row to the west
3	3-10%	165°	264° for 200 feet from end of plot # 2
4	3-10%	165°	adjacent to plot # 3, 1 row to the west
5	3-10%	200°	258° for 200 feet from end of plot #4
6	3-10%	200°	adjacent to plot # 5, 1 row to the west
7	3-10%	195°	294° for 100 feet from end of plot # 6
8	3-10%	195°	adjacent to plot # 7, 1 row to the west
9	3-10%	150°	280° for 200 feet from end of plot # 8
10	3-10%	150°	adjacent to plot # 9, 1 row to the west
11	3-10%	60°	238° for 200 feet from end of plot # 10
12	3-10%	60°	adjacent to plot # 11, 1 row to the north

General comments

There are 6 pairs of plots at this site spaced 100 – 200 feet from the next pair. AP is the only species in the plots.

Plot locations at Kilmer (site #8)

All seedlings at plot # 12 have been dead for several years. This plot was abandoned.

USDA, FS, NA, FHP
MFO, kf 03/17/10

0.1 0.05 0 0.1 Miles

Legend

Plot locations

Slope, aspect and directions for each plot at plot at Kilmer 1 (Site # 8)

Plot #	Slope	Aspect	Directions
1	0-2%	150°	100 feet southeast of erosion gully
2	0-2%	150°	adjacent to plot # 1
3	0-2%	30°	150 feet northwest of erosion gully
4	0-2%	30°	adjacent to plot # 3
5	0-2%	220°	adjacent to six-stemmed silver maple
6	0-2%	220°	220 feet north of plot # 5
7	0-2%	300°	50 feet past beaver dam
8	0-2%	350°	100 feet past plot # 7
9	0-2%	310°	adjacent to "V" shaped pond
10	0-2%	40°	adjacent to painted yellow poplar
11	0-2%	280°	adjacent to plot # 10
12	0-2%	150°	adjacent to plot # 11

General comments

The plots at this site are 30′ x 30′. Most of the planted areas at this un-reclaimed site are rather small. This site has been used extensively by ATV's. VP comprises most of the seedlings along with smaller amounts of NRO and BL. Beavers are present at this site.

APPENDIX B

Survival and height information for each site

and for individual plots

Site # 1 – Fernwood State Forest

Annual survival by species at Fernwood State Forest

Year	GA – 202 planted			NRO – 163 planted			All seedlings – 365 planted		
	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival
2000	201	99.5	99.5	181	92.6	92.6	352	96.4	96.4
2001	199	98.5	99.0	122	74.8	80.8	321	87.9	91.2
2002	194	96.0	97.5	82	50.3	67.2	276	75.6	86.0
2003	186	92.1	95.9	64	39.3	78.0	250	68.5	94.2
2004	183	90.6	98.4	48	29.4	75.0	231	63.3	92.4
2005	180	89.1	98.4	43	26.4	89.6	223	61.1	96.5
2006	179	88.6	99.4	34	20.9	79.1	213	58.4	95.5
2007	177	87.6	98.9	26	16.0	76.5	203	55.6	95.3
2008	175	86.6	98.9	22	13.5	84.6	197	54.0	97.0
2009	175	86.6	100	20	12.3	90.9	195	53.4	99.0

Five, seven and ten year height measurements by species at Fernwood State Forest

Year	GA (in feet)		NRO (in feet)		All species (in feet)	
	Range	Average	Range	Average	Range	Average
2004	.5-5	1.65	.5-1	.85	.5-5	1.5
2006	.5-6	2.1	.5-2	1.3	.5-6	1.95
2009	1-13	2.6	1-3	1.4	1-13	2.5

Survival information by plot at Fernwood State Forest (Site # 1)

Survival of 35 GA planted in plot # 1

Year	# Surviving	% Survival	% Annual survival
2000	35	100	100
2001	34	97.1	97.1
2002	33	94.3	97.1
2003	32	91.4	97.0
2004	32	91.4	100
2005	31	88.6	96.9
2006	31	88.6	100
2007	31	88.6	100
2008	31	88.6	100
2009	31	88.6	100

Survival of 27 NRO planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	25	92.6	92.6
2001	23	85.2	92.0
2002	9	33.3	39.1
2003	8	29.6	88.8
2004	6	22.2	75.0
2005	6	22.2	100
2006	6	22.2	100
2007	5	18.5	83.3
2008	5	18.5	100
2009	4	14.8	80.0

Survival of 28 NRO planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	26	92.9	92.9
2001	21	75.0	80.8
2002	15	53.6	71.4
2003	13	46.4	86.7
2004	12	42.9	92.3
2005	12	42.9	100
2006	10	35.7	83.3
2007	10	35.7	100
2008	8	28.6	80.0
2009	8	28.6	100

Survival of 31 GA planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	31	100	100
2001	31	100	100
2002	29	93.6	93.6
2003	26	83.9	89.7
2004	25	80.6	96.2
2005	24	77.4	96.0
2006	24	77.4	100
2007	24	77.4	100
2008	24	77.4	100
2009	24	77.4	100

Survival of 20 NRO planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	20	100	100
2001	16	80.0	80.0
2002	15	75.0	93.8
2003	13	65.0	86.7
2004	8	40.0	61.5
2005	8	40.0	100
2006	5	25.0	62.5
2007	3	15.0	60.0
2008	2	10.0	66.7
2009	1	5.0	50.0

Survival of 31 GA planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	31	100	100
2001	30	96.8	96.8
2002	30	96.8	100
2003	30	96.8	100
2004	30	96.8	100
2005	30	96.8	100
2006	30	96.8	100
2007	29	93.5	96.7
2008	29	93.5	100
2009	29	93.5	100

Survival information by plot at Fernwood State Forest (Site # 1)

Survival of 33 NRO planted in plot # 7

Year	# Surviving	% Survival	% Annual survival
2000	28	84.8	84.8
2001	20	60.6	71.4
2002	13	39.3	65.0
2003	5	15.2	38.5
2004	3	9.1	60.0
2005	3	9.1	100
2006	3	9.1	100
2007	2	6.1	66.7
2008	2	6.1	100
2009	2	6.1	100

Survival of 46 GA planted in plot # 8

Year	# Surviving	% Survival	% Annual survival
2000	46	100	100
2001	46	100	100
2002	46	100	100
2003	42	91.3	91.3
2004	42	91.3	100
2005	41	89.1	97.6
2006	41	89.1	100
2007	40	86.9	97.6
2008	38	82.6	95.0
2009	38	82.6	100

Survival of 24 NRO planted in plot # 9

Year	# Surviving	% Survival	% Annual survival
2000	23	95.8	95.8
2001	23	95.8	100
2002	20	83.3	87.0
2003	19	79.2	95.0
2004	13	54.2	68.4
2005	8	33.3	61.5
2006	5	20.8	62.5
2007	1	4.2	20.0
2008	1	4.2	100
2009	1	4.2	100

Survival of 29 GA planted in plot # 10

Year	# Surviving	% Survival	% Annual survival
2000	29	100	100
2001	29	100	100
2002	27	93.1	93.1
2003	27	93.1	100
2004	27	93.1	100
2005	27	93.1	100
2006	26	89.7	96.3
2007	26	89.7	100
2008	26	89.7	100
2009	26	89.7	100

Survival of 31 NRO planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	29	93.5	93.5
2001	19	61.3	65.5
2002	10	32.3	52.6
2003	6	19.4	60.0
2004	6	19.4	100
2005	6	19.4	100
2006	5	16.1	83.3
2007	5	16.1	100
2008	4	12.9	80.0
2009	4	12.9	100

Survival of 30 GA planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	29	96.7	96.7
2001	29	96.7	100
2002	29	96.7	100
2003	29	96.7	100
2004	27	90.0	93.1
2005	27	90.0	100
2006	27	90.0	100
2007	27	90.0	100
2008	27	90.0	100
2009	27	90.0	100

Five, seven and ten year height measurements by species for each plot at Fernwood State Forest (Site # 1)

Year	Plot #	Species	Height (in feet)	
			Range	Average
2004	1	GA	.5-3.5	1.65
2006	1	GA	1-6	2.15
2009	1	GA	1-13	3.2
2004	2	NRO	.5-1	0.9
2006	2	NRO	1-1.5	1.15
2009	2	NRO	1-3	1.65
2004	3	NRO	.5-2	1.1
2006	3	NRO	1-2	1.25
2009	3	NRO	1-2.5	1.4
2004	4	GA	.5-3	1.65
2006	4	GA	1-7	2.9
2009	4	GA	1.5-8.5	3.65
2004	5	NRO	all were .5	.5
2006	5	NRO	all were .5	.5
2009	5	NRO	all were 1	.5
2004	6	GA	.5-2.5	1.5
2006	6	GA	.5-2.5	1.6
2009	6	GA	1-2.5	1.7
2004	7	NRO	all were 1	1.0
2006	7	NRO	all were 1.5	1.5
2009	7	NRO	all were 1.5	1.5
2004	8	GA	1-5	2.25
2006	8	GA	1-5.5	2.4
2009	8	GA	1.5-6	2.7
2004	9	NRO	.5-1	.55
2006	9	NRO	all were .5	.5
2009	9	NRO	all were 1	1.0
2004	10	GA	1-2	1.45
2006	10	GA	1-2.5	1.6
2009	10	GA	1-2.5	1.75
2004	11	NRO	.5-1	0.8
2006	11	NRO	.5-1.5	1.0
2009	11	NRO	1-2.5	1.5
2004	12	GA	1-3	1.65
2006	12	GA	1.5-3.5	2.05
2009	12	GA	1-5.5	2.55

Site #2 - - Tri-Valley # 1

Annual survival by species at Tri-Valley # 1

Year	GA – 66 planted			Mixed oaks – 262 planted			All species – 328 planted		
	# Surviving	% Survival	% Annual survival	# Surviving	% Surviving	% Annual survival	# Surviving	% Survival	% Annual survival
2000	62	93.9	93.9	249	95.0	95.0	311	94.8	95.7
2001	59	89.4	95.2	243	92.7	97.6	302	92.1	97.1
2002	59	89.4	100	240	91.6	98.8	299	91.2	99.0
2003	59	89.4	100	236	90.1	98.3	295	89.9	98.7
2004	59	89.4	100	234	89.3	99.1	293	89.3	99.3
2005	59	89.4	100	234	89.3	100	293	89.3	100
2006	58	87.9	98.3	233	88.9	99.6	291	88.7	99.3
2007	58	87.9	100	233	88.9	100	291	88.7	100
2008	57	86.4	98.3	233	88.9	100	290	88.4	99.7
2009	57	86.4	100	233	88.9	100	290	88.4	100

Mixed oaks = NRO and WO

Five, seven and ten year height measurements by species at Tri Valley # 1

Year	GA		Mixed oaks		All species	
	Height (in feet)		Height (in feet)		Height (in feet)	
	Range	Average	Range	Average	Range	Average
2004	.5-3.5	1.5	.5-6.5	3.6	.5-6.5	3.2
2006	.5-6.5	2.0	1-8.5	5.4	1-8.5	4.7
2009	2-8	3.45	.5-16	8.5	.5-16	6.9

Survival information for each plot at Tri Valley Wildlife Area # 1 (Site #2)

Survival of 29 GA planted in plot # 1

Year	# Surviving	% Survival	% Annual survival
2000	25	86.2	96.2
2001	25	86.2	100
2002	25	86.2	100
2003	25	86.2	100
2004	25	86.2	100
2005	25	86.2	100
2006	25	86.2	100
2007	25	86.2	100
2008	25	86.2	100
2009	25	86.2	100

Survival of 36 mixed oaks (NRO & WO) planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	34	94.4	94.4
2001	34	94.4	100
2002	34	94.4	100
2003	33	91.6	97.1
2004	33	91.6	100
2005	33	91.6	100
2006	32	88.9	97.0
2007	32	88.9	100
2008	32	88.9	100
2009	32	88.9	100

Survival of 37 GA planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	37	100	100
2001	34	91.9	91.9
2002	34	91.9	100
2003	34	91.9	100
2004	34	91.9	100
2005	34	91.9	100
2006	33	89.2	97.1
2007	33	89.2	100
2008	32	86.5	97.0
2009	32	86.5	100

Survival of 28 mixed oaks (NRO &WO) planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	24	96.0	969
2001	22	88.0	91.7
2002	22	88.0	100
2003	22	88.0	100
2004	22	88.0	100
2005	22	88.0	100
2006	22	88.0	100
2007	22	88.0	100
2008	22	88.0	100
2009	22	88.0	100

Survival of 32 mixed oaks (NRO &WO) planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	31	96.9	96.9
2001	31	96.9	100
2002	31	96.9	100
2003	31	96.9	100
2004	31	96.9	100
2005	31	96.9	100
2006	31	96.9	100
2007	31	96.9	100
2008	31	96.9	100
2009	31	96.9	100

Survival of 27 NRO planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	26	96.3	96.3
2001	26	96.3	100
2002	25	92.6	96.2
2003	25	92.6	100
2004	23	85.2	92.0
2005	23	85.2	100
2006	23	85.2	100
2007	23	85.2	100
2008	23	85.2	100
2009	23	85.2	100

Survival information for each plot at Tri Valley Wildlife Area # 1 (Site #2)

Survival of 26 NRO planted in plot # 7

Year	# Surviving	% Survival	% Annual survival
2000	25	96.2	96.2
2001	25	96.2	100
2002	25	96.2	100
2003	23	88.5	92.0
2004	23	88.5	100
2005	23	88.5	100
2006	23	88.5	100
2007	23	88.5	100
2008	23	88.5	100
2009	23	88.5	100

Survival of 25 NRO planted in plot # 8

Year	# Surviving	% Survival	% Annual survival
2000	23	92.0	92.0
2001	22	88.0	95.7
2002	22	88.0	100
2003	22	88.0	100
2004	22	88.0	100
2005	22	88.0	100
2006	22	88.0	100
2007	22	88.0	100
2008	22	88.0	100
2009	22	88.0	100

Survival of 20 mixed oaks (NRO &WO) planted in plot # 9

Year	# Surviving	% Survival	% Annual survival
2000	19	95.0	95.0
2001	18	90.0	94.7
2002	17	85.0	94.4
2003	17	85.0	100
2004	17	85.0	100
2005	17	85.0	100
2006	17	85.0	100
2007	17	85.0	100
2008	17	85.0	100
2009	17	85.0	100

Survival of 22 mixed oaks (NRO &WO) planted in plot # 10

Year	# Surviving	% Survival	% Annual survival
2000	22	100	100
2001	22	100	100
2002	22	100	100
2003	21	95.5	95.5
2004	21	95.5	100
2005	21	95.5	100
2006	21	95.5	100
2007	21	95.5	100
2008	21	95.5	100
2009	21	95.5	100

Survival of 23 WO planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	22	95.7	95.7
2001	21	91.3	95.5
2002	20	87.0	95.2
2003	20	87.0	100
2004	20	87.0	100
2005	20	87.0	100
2006	20	87.0	100
2007	20	87.0	100
2008	20	87.0	100
2009	20	87.0	100

Survival of 23 WO planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	23	100	100
2001	22	95.7	95.7
2002	22	95.7	100
2003	22	95.7	100
2004	22	95.7	100
2005	22	95.7	100
2006	22	95.7	100
2007	22	95.7	100
2008	22	95.7	100
2009	22	95.7	100

Five, seven and ten year height measurements by species for each plot at Tri Valley Wildlife Area #1 (Site #2)

Year	Plot #	Species	Height (in feet)	
			Range	Average
2004	1	GA	1-3.5	1.45
2006	1	GA	1-6.5	2.55
2009	1	GA	1.5-8	3.25
2004	2	NRO, WO	.5-6.5	3.65
2006	2	NRO, WO	1-7.5	5.15
2009	2	NRO, WO	1.5-14	8.4
2004	3	GA	.5-3	1.6
2006	3	GA	.5-4.5	2.35
2009	3	GA	1-7	3.65
2004	4	NRO, WO	1-5.5	3.2
2006	4	NRO, WO	1.5-8	5.15
2009	4	NRO, WO	3.5-13.5	8.15
2004	5	NRO, WO	1.5-5	3.7
2006	5	NRO, WO	2.5-8	6.1
2009	5	NRO, WO	4.5-12.5	9.75
2004	6	NRO	1-5.5	2.95
2006	6	NRO	1-8	4.1
2009	6	NRO	.5-13	7.1
2004	7	NRO	.5-5	2.55
2006	7	NRO	1-6	4.15
2009	7	NRO	1-12	6.3
2004	8	NRO	.5-4.5	2.4
2006	8	NRO	1-6.5	3.75
2009	8	NRO	2-10.5	6.15
2004	9	NRO, WO	2.5-6.5	5.0
2006	9	NRO, WO	2.5-9.5	6.75
2009	9	NRO, WO	7-15	10.45
2004	10	NRO, WO	1-6.5	4.45
2006	10	NRO, WO	1-8	6.45
2009	10	NRO, WO	1.5-16	10.45
2004	11	WO	2.5-6	4.5
2006	11	WO	3-8.5	6.6
2009	11	WO	4-13	9.95
2004	12	WO	1-6	4.2
2006	12	WO	2-8	5.95
2009	12	WO	2-12.5	8.55

Site # 3 – Tri Valley # 2

Annual survival by species at Site # 3 – Tri Valley # 2

	All seedlings – 326 planted			NRO – 216 planted		
Year	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival
2000	317	97.2	97.2	207	95.8	95.8
2001	304	93.3	98.9	199	92.1	91.7
2002	293	89.8	96.4	194	89.8	97.5
2003	257	78.9	78.8	159	73.6	82.0
2004	247	75.8	96.1	151	69.9	95.0
2005	244	74.8	98.8	149	69.0	98.7
2006	243	74.6	99.6	149	69.0	100
2007	240	73.6	98.7	147	68.1	98.7
2008	239	73.3	99.6	146	67.6	99.3
2009	236	72.4	98.7	145	67.1	99.3

	GA – 88 planted			SDW – 22 planted		
Year	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival
2000	88	100	100	22	100	100
2001	86	97.7	97.7	19	86.4	86.4
2002	83	94.3	96.5	16	72.7	84.2
2003	83	94.3	100	15	68.2	93.8
2004	82	93.2	98.8	14	63.6	93.3
2005	82	93.2	100	13	59.1	92.9
2006	81	92.0	98.8	13	59.1	100
2007	81	92.0	100	12	54.5	92.3
2008	81	92.0	100	12	54.5	100
2009	81	92.0	100	10	45.5	83.3

Five, seven and ten year height measurements by species at Tri Valley # 2

Year	NRO		GA		SDW		All species	
	Height (in feet)		Height (in feet)		Height (in feet)		Height (in feet)	
	Range	Average	Range	Average	Range	Average	Range	Average
2004	.5-4.5	2.45	1-3.5	2.2	1-2.5	1.2	.5-4.5	4.6
2006	1-6.5	2.9	1-5.5	2.55	.5-2	1.5	.5-6.5	2.65
2009	1-10	4.05	1-7.5	3.9	1-3	1.75	1-10	3.9

Survival information by plot and species at Tri Valley Wildlife Area #2 (Site # 3)

Survival of 27 NRO planted in plot # 1*

Year	# Surviving	% Survival	% Annual survival
2000	26	96.3	96.3
2001	26	96.3	100
2002	26	96.3	100
2003	5	18.5	19.2
2004	5	18.5	100
2005	5	18.5	100
2006	5	18.5	100
2007	5	18.5	100
2008	5	18.5	100
2009	5	18.5	100

Survival of 27 NRO planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	27	100	100
2001	27	100	100
2002	26	96.3	96.3
2003	22	81.5	84.6
2004	19	70.4	86.4
2005	19	70.4	100
2006	19	70.4	100
2007	19	70.4	100
2008	19	70.4	100
2009	19	70.4	100

Survival of 32 NRO planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	32	100	100
2001	31	96.9	96.9
2002	29	90.6	93.5
2003	24	75.0	82.8
2004	22	68.8	91.7
2005	22	68.8	100
2006	22	68.8	100
2007	21	65.6	95.5
2008	21	65.6	100
2009	20	62.6	95.2

Survival of 12 GA planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	12	100	100
2001	12	100	100
2002	12	100	100
2003	12	100	100
2004	11	91.6	91.6
2005	11	91.6	100
2006	10	83.3	90.9
2007	10	83.3	100
2008	10	83.3	100
2009	10	83.3	100

Survival of 10 SDW planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	10	100	100
2001	9	90.0	90.0
2002	7	70.0	77.8
2003	6	60.0	85.7
2004	6	60.0	100
2005	6	60.0	100
2006	6	60.0	100
2007	5	50.0	83.3
2008	5	50.0	100
2009	4	40.0	80.0

* = one GA planted in this plot and is alive after 10 growing seasons

Survival information by plot and species at Tri Valley Wildlife Area #2 (Site # 3)

Survival of 10 GA planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	10	100	100
2001	10	100	100
2002	9	90.0	90.0
2003	9	90.0	100
2004	9	90.0	100
2005	9	90.0	100
2006	9	90.0	100
2007	9	90.0	100
2008	9	90.0	100
2009	9	90.0	100

Survival of 10 SDW planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	10	100	100
2001	8	80.0	80.0
2002	7	70.0	87.5
2003	7	70.0	100
2004	6	60.0	71.5
2005	5	50.0	100
2006	5	50.0	100
2007	5	50.0	100
2008	5	50.0	100
2009	4	40.0	80.0

Survival of 14 NRO planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	14	100	91.6
2001	14	100	100
2002	14	100	100
2003	14	100	100
2004	14	100	100
2005	14	100	100
2006	14	100	100
2007	14	100	100
2008	14	100	100
2009	14	100	100

Survival of 14 GA planted in plot #6

Year	# Surviving	% Survival	% Annual survival
2000	14	100	100
2001	14	100	100
2002	14	100	100
2003	14	100	100
2004	14	100	100
2005	14	100	100
2006	14	100	100
2007	14	100	100
2008	14	100	100
2009	14	100	100

Survival of 12 NRO planted in plot # 7 **

Year	# Surviving	% Survival	% Annual survival
2000	11	91.6	91.6
2001	11	91.6	100
2002	11	91.6	100
2003	11	91.6	100
2004	11	91.6	100
2005	11	91.6	100
2006	11	91.6	100
2007	11	91.6	100
2008	11	91.6	100
2009	11	91.6	100

Survival of 14 GA planted in plot # 7**

Year	# Surviving	% Survival	% Annual survival
2000	14	100	100
2001	12	85.7	85.7
2002	12	85.7	100
2003	12	85.7	100
2004	12	85.7	100
2005	12	85.7	100
2006	12	85.7	100
2007	12	85.7	100
2008	12	85.7	100
2009	12	85.7	100

** = one SDW planted in this plot and is alive after 10 growing seasons

Survival information by plot and species at Tri Valley Wildlife Area #2 (Site # 3)

Survival of 14 NRO planted in plot # 8 **

Year	# Surviving	% Survival	% Annual survival
2000	14	100	100
2001	14	100	100
2002	14	100	100
2003	13	92.9	92.9
2004	12	85.7	92.3
2005	12	85.7	100
2006	12	85.7	100
2007	12	85.7	100
2008	12	85.7	100
2009	12	85.7	100

Survival of 14 GA planted in plot # 8**

Year	# Surviving	% Survival	% Annual survival
2000	14	100	100
2001	14	100	100
2002	14	100	100
2003	14	100	100
2004	14	100	100
2005	14	100	100
2006	14	100	100
2007	14	100	100
2008	14	100	100
2009	14	100	100

Survival of 27 NRO planted in plot # 9***

Year	# Surviving	% Survival	% Annual survival
2000	26	96.3	96.3
2001	26	96.3	100
2002	26	96.3	100
2003	26	96.3	100
2004	26	96.3	100
2005	26	96.3	100
2006	26	96.3	100
2007	26	96.3	100
2008	26	96.3	100
2009	26	96.3	100

Survival of 29 NRO planted in plot # 10

Year	# Surviving	% Survival	% Annual survival
2000	23	79.3	79.3
2001	21	72.4	91.3
2002	19	65.5	90.5
2003	19	65.5	100
2004	18	62.1	94.7
2005	17	58.6	94.4
2006	17	58.6	100
2007	17	58.6	100
2008	17	58.6	100
2009	17	58.6	100

Survival of 22 GA planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	22	100	100
2001	22	100	100
2002	21	95.5	95.5
2003	21	95.5	100
2004	21	95.5	100
2005	21	95.5	100
2006	21	95.5	100
2007	21	95.5	100
2008	21	95.5	100
2009	21	95.5	100

Survival of 5 NRO planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	5	100	100
2001	5	100	100
2002	5	100	100
2003	3	60.0	60.0
2004	2	40.0	66.7
2005	2	40.0	100
2006	2	40.0	100
2007	1	20.0	50.0
2008	1	20.0	100
2009	1	20.0	100

** = one SDW planted in this plot and is alive after 10 growing seasons

*** = one GA planted in this plot and it died in 2002

Survival information by plot and species at Tri Valley wildlife Area #2 (Site # 3)

Survival of 29 NRO planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	29	100	100
2001	24	82.8	82.8
2002	24	82.8	100
2003	22	75.9	91.7
2004	22	75.9	100
2005	21	72.4	95.5
2006	21	72.4	100
2007	21	72.4	100
2008	20	69.0	95.2
2009	20	69.0	100

Five, seven and ten year height measurements by species in each plot for Tri Valley Wildlife Area # 2 (Site # 3)

Year	Plot #	NRO		GA		SDW		All species	
		Height (in feet)		Height (in feet)		Height (in feet)		Height (in feet)	
		Range	Average	Range	Average	Range	Average	Range	Average
2004	1	1-3	1.9	all were 3*	3*	---	---	1-3	2.1
2006	1	1.5-6	3.9	all were 5.5*	5.5*	---	---	1.5-6	4.15
2009	1	3-6	5.3	all were 7.5*	7.5 *	---	---	3-7.5	5.65
2004	2	.5-4	2.1	---	---	---	---	.5-4	2.1
2006	2	1-5.5	3.25	---	---	---	---	1.5-5	3.25
2009	2	1.5-7	4.15	---	---	---	---	1.5-7	4.15
2004	3	1-4	2.25	---	---	---	---	1-4	2.25
2006	3	1-6.5	2.75	---	---	---	---	1-6.5	2.75
2009	3	1.5-10	3.95	---	---	---	---	1.5-10	3.95
2004	4	---	---	1-2.5	1.9	1-2.5	1.25	1-2.5	1.65
2006	4	---	---	1-3	2.2	.5-2	1.6	.5-3	2.0
2009	4	---	---	1.5-5	3.05	1.5-2.5	2.0	1.5-5	2.75
2004	5	---	---	2-3.5	2.9	1-1.5	1.1	1-3.5	2.2
2006	5	---	---	2-4	3.2	1-2	1.4	1-4	2.55
2009	5	---	---	1-7	4.1	1-2	1.5	1-7	3.3
2004	6	2-4.5	3.05	1.5-2.5	2.35	---	---	1.5-4.5	2.7
2006	6	2.5-5.5	4.25	1.5-3.5	2.75	---	---	1.5-5.5	3.5
2009	6	3-8	5.7	2-6	4.05	---	---	2-8	4.9
2004	7	1-4	2.7	2-3	2.15	all were 1.5*	1.5*	1-4	2.3
2006	7	1-6	3.6	2.5-4	2.85	all were 1*	1*	1-6	3.15
2009	7	1-8	5.2	2.5-7	4.2	all were 1*	1*	1-8	4.55
2004	8	1.5-4	2.9	2-3.5	2.6	all were 2*	2*	1.5-4	2.7
2006	8	1.5-6	3.8	2.5-4.5	3.55	all were 2**	2*	1.5-6	3.6
2009	8	2.5-8.5	4.85	2.5-6	4.7	all were 3	3*	2.5-8.5	4.75
2004	9	1-4.5	2.3	---	---	---	---	1-4.5	2.3
2006	9	1-5.5	2.7	---	---	---	---	1-5.5	2.7
2009	9	1-8	3.5	---	---	---	---	1-8	3.5
2004	10	1-3.5	1.95	---	---	---	---	1-3.5	1.95
2006	10	1-3.5	2.35	---	---	---	---	1-3.5	2.35
2009	10	1-5	2.65	---	---	---	---	1-5	2.65
2004	11	.5-1	0.9	1.5-3	1.75	---	---	.5-3	1.7
2006	11	1-1.5	1.15	1.5-3.5	2.25	---	---	1-3.5	2.1
2009	11	1-3	2.0	2-5.5	3.3	---	---	1-5.5	3.25
2004	12	1-3	1.95	---	---	---	---	1-3	1.95
2006	12	1-4.5	2.5	---	---	---	---	1-4.5	2.5
2009	12	2-5.5	2.7	---	---	---	---	2-5.5	2.7

* = based on only one seedling

Site # 4 – Woodbury # 1

Annual survival of mixed oaks (WO and NRO) at Woodbury #1 (Site #4)

Year	Mixed oaks – 276 planted		
	# surviving	% survival	% annual survival
2000	221	80.0	80.0
2001	146	52.9	66.1
2002	132	47.8	90.4
2003	125	45.3	94.7
2004	124	44.9	99.2
2005	122	44.2	98.4
2006	121	43.8	99.2
2007	121	43.8	100
2008	121	43.8	100
2009	119	43.1	98.4

Five, seven and ten year height measurements of mixed oaks at Woodbury #1

Year	Height (in feet)	
	Range	Average
2004	.5-5	2.45
2006	.5-7	3.5
2009	.5-11	4.6

Survival information by plot and species at Woodbury Wildlife Area #1 (Site 4)

Survival of 23 NRO planted in plot # 1

Year	# Surviving	% Survival	% Annual survival
2000	22	95.7	95.7
2001	17	73.9	77.3
2002	16	69.6	94.1
2003	16	69.6	100
2004	16	69.6	100
2005	16	69.6	100
2006	16	69.6	100
2007	16	69.6	100
2008	16	69.6	100
2009	16	69.6	100

Survival of 27 NRO planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	24	88.9	88.9
2001	9	33.3	37.5
2002	9	33.3	100
2003	9	33.3	100
2004	9	33.3	100
2005	9	33.3	100
2006	9	33.3	100
2007	9	33.3	100
2008	9	33.3	100
2009	9	33.3	100

Survival of 24 NRO planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	24	100	100
2001	13	54.2	54.2
2002	12	50.0	92.3
2003	12	50.0	100
2004	12	50.0	100
2005	12	50.0	100
2006	12	50.0	100
2007	12	50.0	100
2008	12	50.0	100
2009	12	50.0	100

Survival of 21 NRO planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	13	61.9	61.9
2001	13	61.9	100
2002	10	47.6	76.9
2003	10	47.6	100
2004	10	47.6	100
2005	10	47.6	100
2006	10	47.6	100
2007	10	47.6	100
2008	10	47.6	100
2009	10	47.6	100

Survival of 26 mixed oaks (WO and NRO) planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	23	88.5	88.5
2001	22	84.6	95.7
2002	19	73.1	86.4
2003	17	65.4	89.5
2004	17	65.4	100
2005	17	65.4	100
2006	17	65.4	100
2007	17	65.4	100
2008	17	65.4	100
2009	17	65.4	100

Survival of 21 NRO planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	13	61.9	61.9
2001	9	42.9	69.2
2002	7	33.3	77.8
2003	6	28.6	85.7
2004	6	28.6	100
2005	6	28.6	100
2006	6	28.6	100
2007	6	28.6	100
2008	6	28.6	100
2009	5	23.8	83.3

Survival information by plot and species at Woodbury Wildlife Area #1 (Site 4)

Survival of 23 NRO planted in plot # 7

Year	# Surviving	% Survival	% Annual survival
2000	21	91.3	91.3
2001	8	34.8	38.1
2002	8	34.8	100
2003	8	34.8	100
2004	8	34.8	100
2005	8	34.8	100
2006	8	34.8	100
2007	8	34.8	100
2008	8	34.8	100
2009	8	34.8	100

Survival of 27 NRO planted in plot # 8

Year	# Surviving	% Survival	% Annual survival
2000	24	88.9	88.9
2001	23	85.2	95.8
2002	23	85.2	100
2003	23	85.2	100
2004	22	81.5	95.7
2005	21	77.8	95.5
2006	21	77.8	100
2007	21	77.8	100
2008	21	77.8	100
2009	21	77.8	100

Survival of 21 NRO planted in plot # 9

Year	# Surviving	% Survival	% Annual survival
2000	13	61.9	61.9
2001	6	28.6	46.2
2002	5	23.8	83.3
2003	4	19.0	80.0
2004	4	19.0	100
2005	4	19.0	100
2006	4	19.0	100
2007	4	19.0	100
2008	4	19.0	100
2009	4	19.0	100

Survival of 22 mixed oaks (WO and NRO) planted in plot # 10

Year	# Surviving	% Survival	% Annual survival
2000	18	81.8	81.8
2001	13	59.1	72.2
2002	12	54.5	92.3
2003	10	45.5	83.3
2004	10	45.5	100
2005	10	45.5	100
2006	9	40.9	90.0
2007	9	40.9	100
2008	9	40.9	100
2009	8	36.4	88.9

Survival of 21 NRO planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	14	66.7	66.7
2001	9	42.9	64.3
2002	7	33.3	77.8
2003	6	28.6	85.7
2004	6	28.6	100
2005	5	23.8	83.3
2006	5	23.8	100
2007	5	23.8	100
2008	5	23.8	100
2009	5	23.8	100

Survival of 20 NRO planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	12	60.0	60.0
2001	4	20.0	33.3
2002	4	20.0	100
2003	4	20.0	100
2004	4	20.0	100
2005	4	20.0	100
2006	4	20.0	100
2007	4	20.0	100
2008	4	20.0	100
2009	4	20.0	100

Five, seven and ten year height measurements by species for each plot at Woodbury Wildlife Area #1 (Site #4)

Year	Plot #	Species	Height (in feet)	
			Range	Average
2004	1	NRO	1-3.5	2.15
2006	1	NRO	.5-4.5	2.55
2009	1	NRO	1-5.5	2.95
2004	2	NRO	1-5	3.05
2006	2	NRO	1-7	5.0
2009	2	NRO	2-11	6.8
2004	3	NRO	1.5-4	2.45
2006	3	NRO	2-6	3.65
2009	3	NRO	1.5-8	2.7
2004	4	NRO	2-4	2.9
2006	4	NRO	2.5-6	4.25
2009	4	NRO	3-6.5	5.3
2004	5	NRO/WO	1-4.5	2.8
2006	5	NRO/WO	1.5-6.5	4.1
2009	5	NRO/WO	1-8.5	5.8
2004	6	NRO	.5-1.5	1.65
2006	6	NRO	1-2.5	1.3
2009	6	NRO	.5-4.5	2.7
2004	7	NRO	1.5-4	2.4
2006	7	NRO	1.5-5	3.45
2009	7	NRO	3-6.5	4.2
2004	8	NRO	1-3.5	2.4
2006	8	NRO	2-6	3.8
2009	8	NRO	2-8	4.9
2004	9	NRO	.5-2.5	1.5
2006	9	NRO	1.5-6	3.4
2009	9	NRO	3-8	5.15
2004	10	NRO/WO	.5-2.5	1.95
2006	10	NRO/WO	1-4.5	2.9
2009	10	NRO/WO	2-6	3.95
2004	11	NRO	1-3	1.65
2006	11	NRO	1-4	2.4
2009	11	NRO	1.5-6	3.8
2004	12	NRO	.5-3	1.65
2006	12	NRO	1-4	2.65
2009	12	NRO	1.5-5.5	4.0

Site 5 Woodbury #2

Annual survival information for species at Woodbury #2 (Site #5)

	GA – 207 planted			NPO - 185 planted			All seedlings – 391 planted		
Year	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival
2000	207	100	100	182	98.9	98.9	389	99.5	99.5
2001	205	99.0	99.0	181	98.4	99.5	386	98.7	99.2
2002	205	99.0	100	176	95.7	97.2	381	97.4	98.7
2003	204	98.6	99.5	176	95.7	100	380	97.2	99.7
2004	192	92.8	94.1	141	76.6	80.1	333	85.2	87.6
2005	192	92.8	100	140	76.1	99.3	332	84.9	99.7
2006	192	92.8	100	139	75.5	99.3	331	84.7	99.7
2007	192	92.8	100	139	75.5	100	331	84.7	100
2008	192	92.8	100	139	75.5	100	331	84.7	100
2009	190	91.8	99.0	139	75.5	100	329	84.1	99.4

Five, seven and ten year height measurements of mixed oaks at Woodbury # 1

Year	GA		NPO		all species	
	Height (in feet)		Height (in feet)		Height (in feet)	
	Range	Average	Range	Average	Range	Average
2004	1-4	2.4	1-5.5	3.6	.5-5.5	2.9
2006	1-5.5	3.2	3-9.5	6.5	1-9.5	4.6
2009	1-11	5.6	2.5-16.5	11.7	1-16.5	7.85

Survival information for each plot at Woodbury Wildlife Area # 2 (Site # 5)

Survival of 31 GA planted in plot # 1

Year	# Surviving	% Survival	% Annual survival
2000	31	100	100
2001	31	100	100
2002	31	100	100
2003	31	100	100
2004	31	100	100
2005	31	100	100
2006	31	100	100
2007	31	100	100
2008	31	100	100
2009	31	100	100

Survival of 38 GA panted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	38	100	100
2001	38	100	100
2002	38	100	100
2003	37	97.4	97.4
2004	36	94.7	97.3
2005	36	94.7	100
2006	36	94.7	100
2007	36	94.7	100
2008	36	94.7	100
2009	36	94.7	100

Survival of 36 GA planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	36	100	100
2001	35	97.2	97.2
2002	35	97.2	100
2003	35	97.2	100
2004	35	97.2	100
2005	35	97.2	100
2006	35	97.2	100
2007	35	97.2	100
2008	35	97.2	100
2009	33	91.7	94.3

Survival of 32 GA planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	32	100	100
2001	32	100	100
2002	32	100	100
2003	32	100	100
2004	32	100	100
2005	32	100	100
2006	32	100	100
2007	32	100	100
2008	32	100	100
2009	32	100	100

Survival of 36 GA planted in plot #5

Year	# Surviving	% Survival	% Annual survival
2000	36	100	100
2001	36	100	100
2002	36	100	100
2003	36	100	100
2004	31	86.1	86.1
2005	31	86.1	100
2006	31	86.1	100
2007	31	86.1	100
2008	31	86.1	100
2009	31	86.1	100

Survival of 34 GA planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	34	100	100
2001	33	97.1	97.1
2002	33	97.1	100
2003	33	97.1	100
2004	27	79.4	81.8
2005	27	79.4	100
2006	27	79.4	100
2007	27	79.4	100
2008	27	79.4	100
2009	27	79.4	100

Survival information for each plot at Woodbury Wildlife Area # 2 (Site # 5)

Survival of 30 NPO planted in plot # 7

Year	# Surviving	% Survival	% Annual survival
2000	30	100	100
2001	29	96.7	96.7
2002	29	96.7	100
2003	29	96.7	100
2004	10	33.3	34.5
2005	9	30.0	90.0
2006	9	30.0	100
2007	9	30.0	100
2008	9	30.0	100
2009	9	30.0	100

Survival of 31 NPO planted in plot # 8

Year	# Surviving	% Survival	% Annual survival
2000	31	100	100
2001	31	100	100
2002	30	96.7	96.7
2003	30	96.7	100
2004	14	45.2	46.7
2005	14	45.2	100
2006	14	45.2	100
2007	14	45.2	100
2008	14	45.2	100
2009	14	45.2	100

Survival of 28 NPO planted in plot # 9

Year	# Surviving	% Survival	% Annual survival
2000	28	100	100
2001	28	100	100
2002	28	100	100
2003	28	100	100
2004	28	100	100
2005	28	100	100
2006	28	100	100
2007	28	100	100
2008	28	100	100
2009	28	100	100

Survival of 34 NPO planted in plot # 10

Year	# Surviving	% Survival	% Annual survival
2000	32	94.1	94.1
2001	32	94.1	100
2002	30	88.2	93.8
2003	30	88.2	100
2004	30	88.2	100
2005	30	88.2	100
2006	30	88.2	100
2007	30	88.2	100
2008	30	88.2	100
2009	30	88.2	100

Survival of 30 NPO planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	30	100	100
2001	30	100	100
2002	29	96.7	96.7
2003	29	96.7	100
2004	29	96.7	100
2005	29	96.7	100
2006	29	96.7	100
2007	29	96.7	100
2008	29	96.7	100
2009	29	96.7	100

Survival of 31 NPO planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	31	100	100
2001	31	100	100
2002	30	96.8	96.8
2003	30	96.8	100
2004	30	96.8	100
2005	30	96.8	100
2006	29	93.5	96.7
2007	29	93.5	100
2008	29	93.5	100
2009	29	93.5	100

Five, seven and ten year height measurements by species for each plot at Woodbury Wildlife Area #2 (Site # 5)

Year	Plot #	Species	Height (in feet)	
			Range	Average
2004	1	GA	1.5-3	2.35
2006	1	GA	1.5-4.5	2.7
2009	1	GA	2-7	3.9
2004	2	GA	1-4	2.15
2006	2	GA	1-4.5	2.8
2009	2	GA	1-6.5	3.65
2004	3	GA	1.5-4	2.6
2006	3	GA	1-5.5	2.9
2009	3	GA	1.5-8.5	4.85
2004	4	GA	1.5-3.5	2.65
2006	4	GA	1-4.5	3.25
2009	4	GA	1-6.5	4.85
2004	5	GA	1-3.5	2.2
2006	5	GA	2-5.5	3.6
2009	5	GA	2-10	6.75
2004	6	GA	1-3.5	2.35
2006	6	GA	2-5.5	4.05
2009	6	GA	3-11	7.65
2004	7	NPO	2-7	4.5
2006	7	NPO	3-9.5	7.7
2009	7	NPO	6.5-16	13.1
2004	8	NPO	1-5.5	3.75
2006	8	NPO	3.5-9	7.1
2009	8	NPO	6-16	13.05
2004	9	NPO	2-5	3.8
2006	9	NPO	4-8.5	6.95
2009	9	NPO	6.5-15	12.25
2004	10	NPO	2-4.5	3.1
2006	10	NPO	2.5-7.5	6.15
2009	10	NPO	4.5-15	11.35
2004	11	NPO	2-8	3.7
2006	11	NPO	3-8.5	6.4
2009	11	NPO	2.5-16.5	10.9
2004	12	NPO	2-5.5	3.4
2006	12	NPO	3.5-8	6.4
2009	12	NPO	2.5-14	11.15

Site # 6 - Egypt Valley

Annual survival by species at Egypt Valley Wildlife Area (Site # 6)

Year	VP - 149 planted			SDW - 31 planted			Mixed oak -133 planted		
	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival
2000	130	87.2	87.2	27	87.1	87.1	123	92.5	92.5
2001	118	79.2	90.8	27	87.1	100	114	85.7	92.7
2002	69	46.3	58.5	27	87.1	100	106	79.7	93.0
2003	5	3.4	7.2	27	87.1	100	95	71.4	89.6
2004	1	.7	20.0	26	83.9	96.3	78	58.6	82.1
2005	1	.7	100	26	83.9	100	70	52.6	84.7
2006	0	0	0	26	83.9	100	60	45.1	83.3
2007	0	0	0	26	83.9	100	56	42.1	93.3
2008	0	0	0	26	83.9	100	54	40.6	96.4
2009	0	0	0	26	83.9	100	50	37.6	92.6

Mixed oaks = NRO, SO and WO

Year	83 Ash planted			All seedlings - 396 planted		
	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival
2000	80	96.4	96.4	360	90.9	90.9
2001	75	90.4	93.8	334	84.3	92.8
2002	69	83.1	92.0	271	68.4	81.8
2003	62	74.7	89.9	189	47.7	69.7
2004	61	73.5	98.4	166	41.9	87.8
2005	60	72.3	98.4	157	39.6	94.6
2006	57	68.7	95.0	143	36.1	91.1
2007	57	68.7	100	139	35.1	97.2
2008	56	67.5	98.2	136	34.3	97.8
2009	54	65.1	93.4	130	32.8	95.6

Five, seven and ten year height measurements at Egypt Valley Wildlife Area

	SDW		Mixed oaks		Ash		all species	
	Height (in feet)		Height (in feet)		Height (in feet)		Height (in feet)	
Year	Range	Average	Range	Average	Range	Average	Range	Average
2004	.5-4	1.55	5-4.5	1.35	.5-3	1.5	.5-4.5	1.45
2006	1.5-4	1.7	.5-6.5	2.15	1-4.0	1.85	.5-6.5	1.95
2009	1.5-3.5	2.3	.5-10	3.45	1-8.0	2.55	.5-10	2.95

Survival information by species for each plot at Egypt Valley Wildlife Area (Site # 6)

Survival of 29 VP planted in plot # 1

Year	# Surviving	% Survival	% Annual survival
2000	24	82.8	82.8
2001	21	72.4	88.0
2002	16	55.2	76.2
2003	1	3.4	6.3
2004	1	3.4	100
2005	1	3.4	100
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 13 WO planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	13	100	100
2001	12	92.3	92.3
2002	11	84.6	91.7
2003	10	76.9	90.9
2004	8	61.5	80.0
2005	4	30.8	50.0
2006	4	30.8	100
2007	4	30.8	100
2008	4	30.8	100
2009	4	30.8	100

Survival of 19 SDW planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	18	94.7	94.7
2001	18	94.7	100
2002	18	94.7	100
2003	18	94.7	100
2004	18	94.7	100
2005	18	94.7	100
2006	18	94.7	100
2007	18	94.7	100
2008	18	94.7	100
2009	18	94.7	100

Survival of 26 VP planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	24	92.3	92.3
2001	22	95.7	91.7
2002	10	38.5	45.5
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 9 GA planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	7	77.8	77.8
2001	6	66.6	85.7
2002	2	22.2	33.3
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival information by plot and species at Egypt Valley Wildlife Area (Site # 6)

Survival of 19 GA planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	18	94.7	94.7
2001	17	89.5	94.4
2002	16	84.2	94.1
2003	13	68.4	81.3
2004	12	63.2	92.3
2005	12	63.2	100
2006	9	47.4	75.0
2007	9	47.4	100
2008	9	47.4	100
2009	8	42.1	88.9

Survival of 16 VP planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	14	87.5	87.5
2001	12	78.0	85.7
2002	9	56.3	75.0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 20 GA planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	20	100	100
2001	17	85.0	85.0
2002	17	85.0	100
2003	15	75.0	88.2
2004	15	75.0	100
2005	14	70.0	93.3
2006	14	70.0	100
2007	14	70.0	100
2008	14	70.0	100
2009	13	65.0	92.9

Survival of 20 VP planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	17	85.0	85.0
2001	15	75.0	88.2
2002	7	35.0	46.6
2003	2	100	28.5
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 22 mixed oaks (WO, NRO and SO) planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	17	77.3	77.3
2001	15	68.2	88.2
2002	9	40.9	60.0
2003	4	18.2	44.4
2004	4	18.2	100
2005	3	13.6	75.0
2006	2	9.1	66.7
2007	2	9.1	100
2008	2	9.1	100
2009	2	9.1	100

Survival of 12 SDW planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	9	75.0	75.0
2001	9	75.0	100
2002	9	75.0	100
2003	9	75.0	100
2004	8	66.7	88.9
2005	8	66.7	100
2006	8	66.7	100
2007	8	66.7	100
2008	8	66.7	100
2009	8	66.7	100

Survival information by plot and species at Egypt Valley Wildlife Area (Site # 6)

Survival of 29 VP planted in plot # 7

Year	# Surviving	% Survival	% Annual survival
2000	27	93.1	93.1
2001	27	93.1	100
2002	16	55.2	59.3
2003	1	3.4	6.3
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 29 VP planted in plot # 8

Year	# Surviving	% Survival	% Annual survival
2000	24	82.0	82.8
2001	21	72.4	87.5
2002	11	37.9	52.4
2003	1	3.4	9.1
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 37 mixed oaks (WO, NRO and SO) planted in plot # 9

Year	# Surviving	% Survival	% Annual survival
2000	33	89.2	89.2
2001	28	75.7	84.8
2002	27	73.0	96.4
2003	24	64.9	88.9
2004	12	32.4	50.0
2005	9	24.3	75.0
2006	3	8.1	33.3
2007	1	2.7	33.3
2008	0	0	0
2009	0	0	0

Survival of 35 GA planted in plot # 10

Year	# Surviving	% Survival	% Annual survival
2000	35	100	100
2001	35	100	100
2002	34	97.1	97.1
2003	34	97.1	100
2004	34	97.1	100
2005	34	97.1	100
2006	34	97.1	100
2007	34	97.1	100
2008	33	94.3	97.1
2009	33	94.3	100

Survival of 29 SO planted in plot # 11**

Year	# Surviving	% Survival	% Annual survival
2000	29	100	100
2001	28	96.6	96.6
2002	28	96.6	100
2003	27	93.1	96.4
2004	25	86.2	92.6
2005	25	86.2	100
2006	22	75.9	88.0
2007	21	72.4	95.5
2008	20	69.0	95.2
2009	17	65.5	95.0

Survival of 31 SO planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	30	96.7	96.7
2001	30	96.7	100
2002	30	96.7	100
2003	30	96.7	100
2004	29	93.6	96.7
2005	29	93.6	100
2006	29	93.6	100
2007	28	90.3	96.6
2008	28	90.3	100
2009	27	87.1	96.4

** = one saw tooth oak planted in this plot and it died in 2003.

Five, seven and ten year height measurements by species for each plot at Egypt Valley Wildlife Area (Site # 6)

Year	Plot #	WO, NRO, SO Height (in feet)		GA Height (in feet)		SDW Height (in feet)		All species Height (in feet)	
		Range	Average	Range	Average	Range	Average	Range	Average
2004	2	.5-1.5	1.0			1.5-4	1.7	.5-4	1.5
2006	2	.5-1.5	0.9			1.5-4	1.7	.5-4	1.55
2009	2	.5-6	2.25			2.5-3.5	2.35	.5-6	2.35
2004	4			1-3	1.55			1-3	1.55
2006	4			1-2	1.61			1-2	1.65
2009	4			1.5-7	3.15			1.5-7	3.15
2004	5			.5-2.5	1.4			.5-2.5	1.4
2006	5			1.5-4	2.0			1.5-4	2.0
2009	5			2-8	3.2			2-8	3.2
2004	6	1-1.5	1.15			.5-2.5	1.25	.5-2.5	1.2
2006	6	1-1.5	1.0			1-2.5	1.7	1-2.5	1.55
2009	6	1-1.5	1.25			1.5-3	2.2	1-3	2.0
2004	9	.5-1.5	1.0					.5-1.5	1.0
2006	9	1-1.5	1.4					1-1.5	1.4
2009	9	*	*					*	*
2004	10			.5-2.5	1.55			.5-2.5	1.55
2006	10			1-3.5	1.85			1-3.5	1.85
2009	10			1-6.5	2.45			1-6.5	2.45
2004	11	.5-3	1.8					.5-3	1.8
2006	11	1-5	2.15					1-5	2.15
2009	11	1-7.5	2.75					1-7.5	2.75
2004	12	1-4.5	1.45					1-4.5	1.45
2006	12	1-6.5	2.45					1-6.5	2.45
2009	12	1-10	4.45					1-10	4.45

Plot # 1 29 VP planted, all were dead by 2005, no height measurements taken
Plot # 3 26 VP and 9 GA planted, all were dead by 2003, no height measurements taken
Plot # 4 16 VP planted, all were dead by 2003, no height measurements taken
Plot # 5 20 VP planted, all were dead by 2004, no height measurements taken
Plot # 7 & 8 29 VP in each plot, all were dead by 2004, no height measurements taken

* = all of this species dead at this time, no more height measurements taken

Site # 7 - High Hill

Annual survival information for 378 AP at High Hill (Site # 7)

Year	# surviving	% survival	% annual survival
2000	312	82.5	82.5
2001	264	69.8	84.6
2002	251	66.4	95.1
2003	227	60.1	90.4
2004	211	55.8	93.0
2005	204	54.0	96.7
2006	203	53.7	99.5
2007	202	53.4	99.5
2008	201	53.2	99.5
2009	201	53.2	100

Five, seven and ten year height measurements at High Hill (Site # 7)

	Height (in feet)	
	Range	Average
2004	1-4	2.45
2006	1-6.5	3.4
2009	1-12	6.25

Survival information by plot for High Hill (Site # 7)

Survival of 29 AP planted in plot # 1

Year	# Surviving	% Survival	% Annual survival
2000	27	93.1	93.1
2001	24	82.8	88.9
2002	23	79.3	95.8
2003	20	69.0	87.0
2004	20	69.0	100
2005	20	69.0	100
2006	20	69.0	100
2007	20	69.0	100
2008	20	69.0	100
2009	20	69.0	100

Survival of 27 AP planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	19	70.4	70.4
2001	11	40.7	57.9
2002	9	33.3	81.8
2003	8	29.6	88.9
2004	8	25.9	100
2005	7	25.9	87.5
2006	7	25.9	100
2007	7	25.9	100
2008	7	25.9	100
2009	7	25.9	100

Survival of 29 AP planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	25	86.2	86.2
2001	20	69.0	80.0
2002	19	65.5	95.0
2003	18	62.1	94.7
2004	17	58.6	94.4
2005	17	58.6	100
2006	17	58.6	100
2007	17	58.6	100
2008	17	58.6	100
2009	17	58.6	100

Survival of 32 AP planted in plot # 4

Year	# Surviving	% Survival	% Annual survival
2000	20	62.5	62.5
2001	19	59.4	95.0
2002	19	59.4	100
2003	19	59.4	100
2004	16	50.0	84.2
2005	16	50.0	100
2006	16	50.0	100
2007	16	50.0	100
2008	16	50.0	100
2009	16	50.0	100

Survival of 38 AP planted in plot # 5

Year	# Surviving	% Survival	% Annual survival
2000	29	76.3	76.3
2001	28	73.7	96.6
2002	26	68.4	92.9
2003	24	63.2	92.3
2004	23	60.5	95.8
2005	20	52.6	87.0
2006	20	52.6	100
2007	20	52.6	100
2008	20	52.6	100
2009	20	52.6	100

Survival of 34 AP planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	28	82.4	82.4
2001	26	76.5	92.9
2002	26	76.5	100
2003	25	73.5	96.2
2004	24	70.6	96.0
2005	21	61.8	84.0
2006	20	58.8	95.2
2007	20	58.8	100
2008	20	58.8	100
2009	20	58.8	100

Survival information by plot for High Hill (Site # 7)

Survival of 27 AP planted in plot # 7

Year	# Surviving	% Survival	% Annual survival
2000	23	85.2	85.2
2001	18	66.7	78.3
2002	18	66.7	100
2003	17	63.0	94.4
2004	15	55.6	88.2
2005	15	55.6	100
2006	15	55.6	100
2007	15	55.6	100
2008	15	55.6	100
2009	15	55.6	100

Survival of 29 AP planted in plot # 8

Year	# Surviving	% Survival	% Annual survival
2000	27	93.1	93.1
2001	24	82.8	88.9
2002	22	75.9	91.7
2003	21	72.4	95.5
2004	21	72.4	100
2005	21	72.4	100
2006	21	72.4	100
2007	21	72.4	100
2008	21	72.4	100
2009	21	72.4	100

Survival of 31 AP planted in plot # 9

Year	# Surviving	% Survival	% Annual survival
2000	30	96.8	96.8
2001	24	77.4	80.0
2002	23	74.2	95.8
2003	20	64.5	87.0
2004	16	51.6	80.0
2005	16	51.6	100
2006	16	51.6	100
2007	15	48.4	93.8
2008	14	45.2	93.3
2009	14	45.2	100

Survival of 28 AP planted in plot # 10

Year	# Surviving	% Survival	% Annual survival
2000	20	71.4	71.4
2001	17	60.7	85.0
2002	15	53.6	88.2
2003	10	35.7	66.7
2004	10	35.7	100
2005	10	35.7	100
2006	10	35.7	100
2007	10	35.7	100
2008	10	35.7	100
2009	10	35.7	100

Survival of 36 AP planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	29	80.6	80.6
2001	24	66.7	82.8
2002	23	63.9	95.8
2003	20	55.6	87.0
2004	20	55.6	100
2005	20	55.6	100
2006	20	55.6	100
2007	20	55.6	100
2008	20	55.6	100
2009	20	55.6	100

Survival of 38 AP planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	35	89.7	89.7
2001	29	76.3	82.9
2002	28	73.7	96.6
2003	25	65.8	89.3
2004	21	55.3	84.0
2005	21	55.3	100
2006	21	55.3	100
2007	21	55.3	100
2008	21	55.3	100
2009	21	55.3	100

Five, seven and ten year height measurements by plot for High Hill (Site # 7)

Year	Plot #	Species	Height (in feet)	
			Range	Average
2004	1	AP	1.5-3.5	3.3
2006	1	AP	2-5.5	3.9
2009	1	AP	3-12	7.2
2004	2	AP	1.5-3	2.3
2006	2	AP	2-6.5	4.05
2009	2	AP	4.5-12	7.8
2004	3	AP	1-3.5	2.45
2006	3	AP	1.5-5	3.65
2009	3	AP	2.5-9.5	6.7
2004	4	AP	1-3.5	2.75
2006	4	AP	2-6.5	4.1
2009	4	AP	4-11.5	7.65
2004	5	AP	1-4	3.2
2006	5	AP	3-6.5	4.15
2009	5	AP	4-11.5	7.8
2004	6	AP	1-4	2.6
2006	6	AP	1.5-5.5	3.9
2009	6	AP	2-10	7.35
2004	7	AP	1.5-3	2.2
2006	7	AP	1.5-3.5	2.95
2009	7	AP	2-6.5	4.55
2004	8	AP	1.5-4	2.4
2006	8	AP	2-5	2.95
2009	8	AP	3-9	4.85
2004	9	AP	1.5-3.5	2.1
2006	9	AP	1.5-5	3.05
2009	9	AP	2.5-7.5	5.85
2004	10	AP	1-3	1.95
2006	10	AP	2-4	2.95
2009	10	AP	3.5-7.5	5.5
2004	11	AP	1.5-3.5	2.3
2006	11	AP	1.5-4.5	2.95
2009	11	AP	2-9	5.3
2004	12	AP	1-3	1.9
2006	12	AP	1-4.5	2.3
2009	12	AP	1-8	4.3

Site #8 – Kilmer

Annual survival information by species at Kilmer (Site #8)

	VP – 281 planted			BL - 86 planted			NRO - 22 planted		
Year	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival	# surviving	% survival	% annual survival
2000	153	54.4	54.4	12	14.0	14.0	9	40.9	40.9
2001	110	39.1	71.9	2	2.3	16.7	9	40.9	100
2002	92	32.7	83.6	0	0	0	9	40.9	100
2003	81	28.8	88.0	0	0	0	7	31.8	77.8
2004	78	27.8	96.3	0	0	0	6	27.3	83.3
2005	77	27.4	98.7	0	0	0	6	27.3	100
2006	76	27.0	98.7	0	0	0	6	27.3	100
2007	75	26.7	98.7	0	0	0	6	27.3	100
2008	74	26.3	98.7	0	0	0	4	18.2	66.7
2009	72	25.6	97.3	0	0	0	3	13.6	75.0

	All seedlings – 389 planted		
Year	# surviving	% survival	% annual survival
2000	174	45.2	45.2
2001	121	31.1	68.8
2002	101	26.0	83.5
2003	88	22.6	87.1
2004	84	21.6	95.5
2005	83	21.3	98.8
2006	82	21.1	98.8
2007	81	20.8	98.8
2008	78	20.1	96.3
2009	75	19.3	96.2

Five, seven and ten year measurements by species at Kilmer

VP			NRO		All species	
hight (in feet)			height (in feet)		height (in feet)	
Year	Range	Average	Range	Average	Range	Average
2004	1-9	4.45	1.5-4	2.4	1-9	4.3
2006	1-13	6.95	1.5-4.5	2.75	1-13	6.65
2009	1-20	10.5	1.5-3	2.35	1-20	10.15

Survival information by species for each plot at Kilmer (Site # 8)

Survival of 22 VP planted in plot # 1*

Year	# Surviving	% Survival	% Annual survival
2000	11	50.0	50.0
2001	10	45.5	90.9
2002	10	45.5	100
2003	8	36.4	80.0
2004	6	27.3	75.0
2005	6	27.3	100
2006	6	27.3	100
2007	6	27.3	100
2008	6	27.3	100
2009	6	27.3	100

Survival of 9 BL planted in plot # 1*

Year	# Surviving	% Survival	% Annual survival
2000	1	11.1	11.1
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 40 VP planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	16	40.0	40.0
2001	9	22.5	56.3
2002	7	17.5	77.8
2003	5	12.5	71.4
2004	5	12.5	100
2005	4	10.0	80.0
2006	4	10.0	100
2007	4	10.0	100
2008	4	10.0	100
2009	4	10.0	100

Survival of 6 BL planted in plot # 2

Year	# Surviving	% Survival	% Annual survival
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 27 VP planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	21	77.8	77.8
2001	20	74.1	95.2
2002	20	74.1	100
2003	20	74.1	100
2004	20	74.1	100
2005	20	74.1	100
2006	20	74.1	100
2007	20	74.1	100
2008	19	70.4	95.0
2009	19	70.4	100

Survival of 5 BL planted in plot # 3

Year	# Surviving	% Survival	% Annual survival
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

* = 2 NRO planted in this plot, one died in 2003 while the other died in 2004

Survival information by species for each plot at Kilmer (Site # 8)

Survival 31 VP planted in plot # 4*

Year	# Surviving	% Survival	% Annual survival
2000	18	58.1	58.1
2001	12	38.7	66.7
2002	11	35.5	91.7
2003	10	32.3	90.9
2004	10	32.3	100
2005	10	32.3	100
2006	10	32.3	100
2007	10	32.3	100
2008	10	32.3	100
2009	9	29.0	90.0

Survival of 7 BL planted in plot # 4*

Year	# Surviving	% Survival	% Annual survival
2000	2	28.6	28.6
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 21 VP planted in plot # 5**

Year	# Surviving	% Survival	% Annual survival
2000	16	76.2	76.2
2001	12	57.1	75.0
2002	12	57.1	100
2003	12	57.1	100
2004	12	57.1	100
2005	12	57.1	100
2006	12	57.1	100
2007	12	57.1	100
2008	12	57.1	100
2009	11	52.4	91.7

Survival of 2 BL planted in plot # 5**

Year	# Surviving	% Survival	% Annual survival
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 16 VP planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	7	43.8	43.8
2001	5	31.3	71.4
2002	5	31.3	100
2003	5	31.3	100
2004	5	31.3	100
2005	5	31.3	100
2006	4	25.0	80.0
2007	3	18.8	75.0
2008	3	18.8	100
2009	3	18.8	100

Survival of 11 BL planted in plot # 6

Year	# Surviving	% Survival	% Annual survival
2000	1	9.1	9.1
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

* = 2 NRO planted in this plot, one died in 2003 while the other died in 2008

** = 5 NRO planted in this plot, 3 died in 2000, one died in 2008 while the other is still alive in 2009

Survival information by species for each plot at Kilmer (Site # 8)

Survival of 10 VP planted in plot # 10**

Year	# Surviving	% Survival	% Annual survival
2000	3	30.0	30.0
2001	1	10.0	33.0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 12 BL planted in plot # 10**

Year	# Surviving	% Survival	% Annual survival
2000	2	16.7	16.7
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 13 VP planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	7	53.8	53.8
2001	3	23.1	42.9
2002	3	23.1	100
2003	3	23.1	100
2004	3	23.1	100
2005	3	23.1	100
2006	3	23.1	100
2007	3	23.1	100
2008	3	23.1	100
2009	3	23.1	100

Survival of 7 BL planted in plot # 11

Year	# Surviving	% Survival	% Annual survival
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 12 VP planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	2	16.7	16.7
2001	1	8.3	50.0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

Survival of 9 BL planted in plot # 12

Year	# Surviving	% Survival	% Annual survival
2000	2	22.2	22.2
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	0	0
2008	0	0	0
2009	0	0	0

** = 3 alders were planted in this plot, one died in 2000, one died in 2004 while the other was still alive in 2009. Due to the small quantity (3) of alder seedlings, they are not included in any of the row data or site data or overall data. Six NRO were also planted in this plot. All died in 2000.

Five, seven and ten year height measurements by species in each plot at Kilmer (Site #8)

Year	Plot #	VP		NRO		All species	
		Height		Height		Height	
		Range	Average	Range	Average	Range	Average
2004	1	.5-8.5	5.4	**	**	.5-8.5	5.4
2006	1	6-11	7.75	**	**	6-11	7.75
2009	1	12-16	13.4	**	**	12-16	13.4
2004	2	1-7	4.9	--	--	1-7	4.9
2006	2	9-10	9.65	--	--	9-10	9.65
2009	2	13.5-16	15.15	--	--	13.5-16	15.15
2004	3	2.5-8	4.95	--	--	2.5-8	4.95
2006	3	4-11.5	7.65	--	--	4-11.5	7.65
2009	3	1-17	11.75	--	--	1-17	11.75
2004	4	1.5-5	2.95	all were 3.5*	all were 3.5*	1.5-5	3.0
2006	4	4.5-7	5.5	all were 3*	all were 4.0 *	4.5-7	5.25
2009	4	3-7.5	5.4	**	**	3-7.5	5.4
2004	5	2-7.5	5.9	1.5-3.5	2.5	2-7.5	5.4
2006	5	4-12	9.6	1.5-3.5	2.5	4-12	8.6
2009	5	4.5-20	15.3	all were 1.5*	all were 1.5 *	1.5-20	14.15
2004	6	4-9	6.8	--	--	4-9	6.8
2006	6	1-13.5	7.9	--	--	1-13.5	7.9
2009	6	9-20	15.0	--	--	9-20	15.0
2004	7	2-3.5	2.65	--	--	2-3.5	2.65
2006	7	2.5-4.5	3.6	--	--	2.5-4.5	3.6
2009	7	4.5-7	4.9	--	--	4.5-7	5.9
2004	8	1-4	2.5	--	--	1-4	2.5
2006	8	3.5-5.5	5.0	--	--	4.5-5.5	5.0
2009	8	6-6.5	6.25	--	--	6-6.5	6.25
2004	9	1-7.5	4.1	1.5-4	2.35	1-7.5	3.65
2006	9	3-8	5.4	2-4.5	2.85	2-8	4.75
2009	9	5-9.5	6.0	2.5-3	2.75	2.5-9.5	5.4
2004	11	1.5-6.5	4.35	--	--	1.5-6.5	4.35
2006	11	2-10.5	7.35	--	--	2-10.5	7.35
2009	11	3-15	10.65	--	--	3-5	10.65

BL was planted in every plot. All had died by 2002, no height measurements taken
* = based on only one seedling
** = all of this species dead at this time, no height measurements taken

APPENDIX C

Seedling and site photos

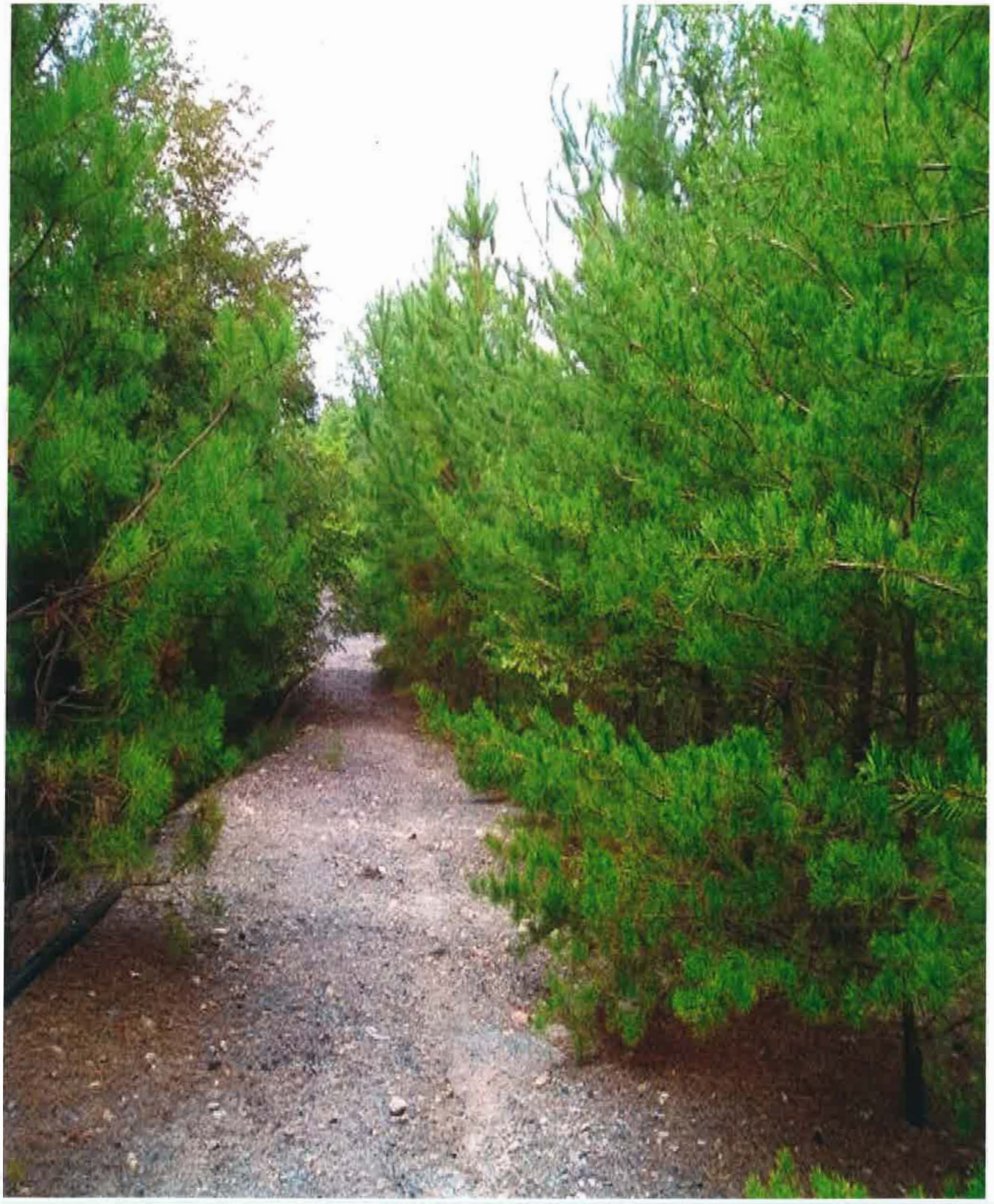
Photo taken near the end of plot #s 1 and 2 at Site # 1 (Fernwood State Forest) in 2004

Approximately same view as proceeding page but in 2009. Scattered green ash are taller than the herbaceous layer. BL "islands" have really grown.

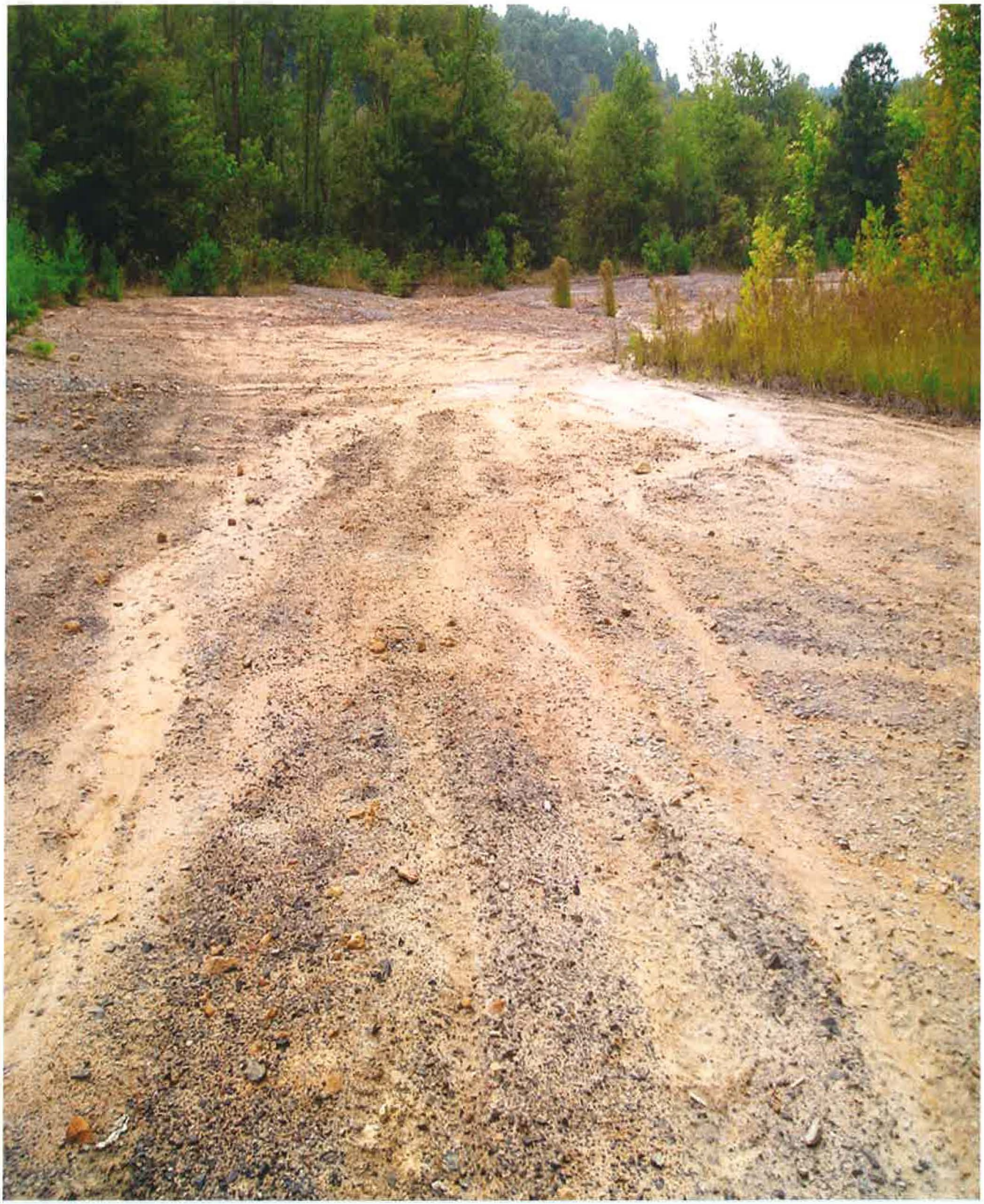
Portion of Site # 6 in 2004

Approximately same view as proceeding page but in 2009. This photo was shifted to the right slightly as the small Autumn olive in the center of the proceeding page is now located on the left edge of this photo.

Virginia pine growing in and near plot # 5 at Kilmer (Site # 8) in 2004.



Approximately same view as proceeding page but in 2009.



Area between plot #s 10 and 11 at Kilmer in 2004. Area was used extensively by ATVs.

Approximately same view as proceeding page but in 2009.

Austrian pine growing in and near plot #s 1 and 2 at High Hill (Site # 7) in 2004.

Approximately same view as proceeding page but in 2009.

Stunted green ash after 5 growing seasons. Seedling was located to an Autumn olive.

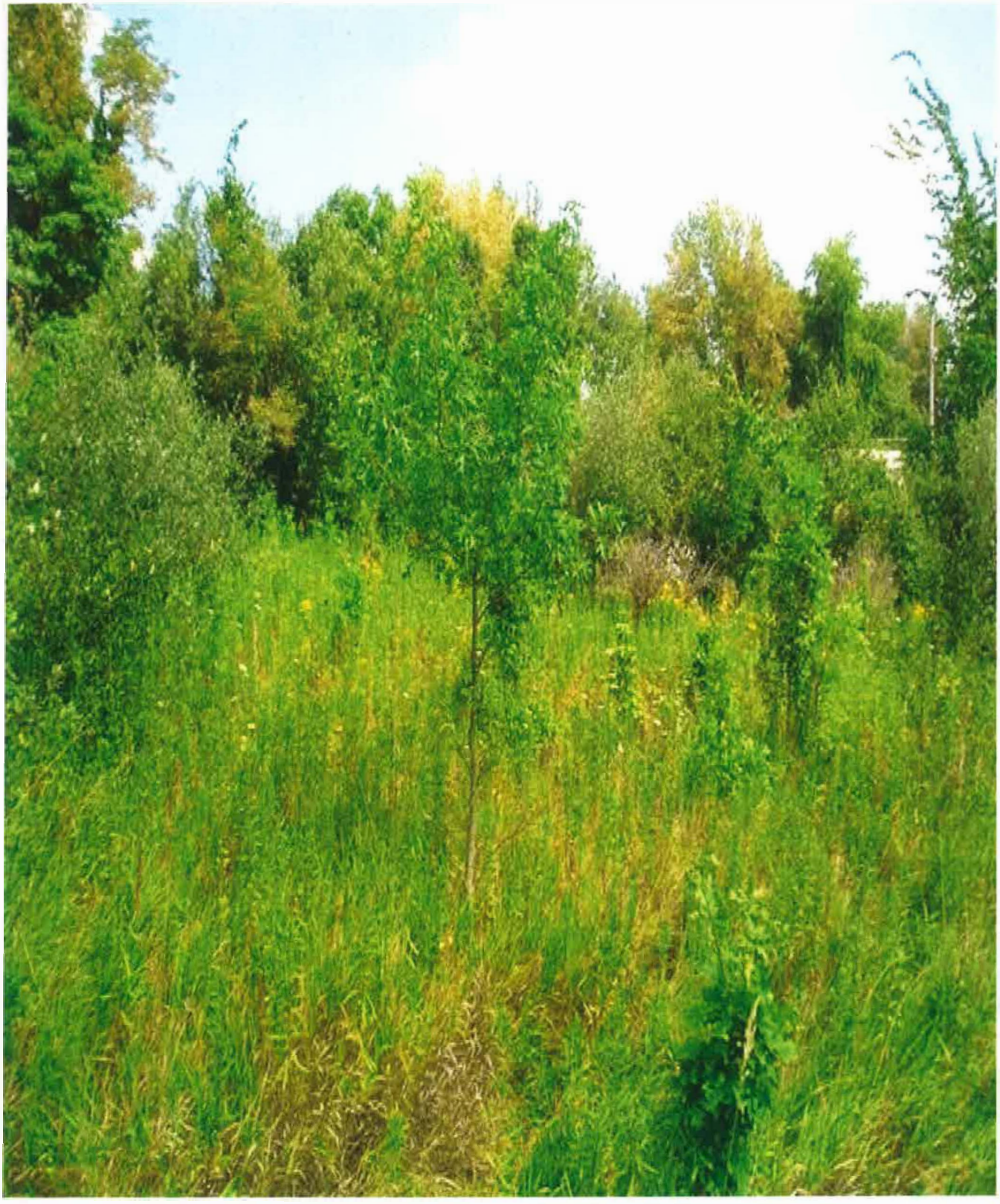
Stunted green ash after 10 growing seasons.

Healthy oaks in plot # 2 of Site # 2 in 2004. Average height of the plot is 3.65 feet.

Approximately same view as proceeding page but in 2009. Average height of the plot is 8.4 feet.

Healthy green ash after 5 growing seasons.

Start of plot # 2 at Site # 6 (Egypt Valley) in 2004. Autumn olive has already taken over this plot.



A large healthy oak at Site #6 (Egypt Valley) in 2009.

Autumn olive out-competing an oak at Site # 3 in 2009.

Three oak seedlings vs. Autumn olive at Egypt Valley in 2009.

Beaver damaged Virginia pine at Kilmer (Site # 8).

Portion of plot # 7 at Woodbury # 2 in 2009. Most of these oaks are 14-16 feet tall.

Large oak seedling at Site # 2 in 2009.

Large and healthy AP after ten growing seasons.

USDA United States Department of Agriculture | Forest Service | Northeastern Area State and Private Forestry | 180 Canfield Street Morgantown, WV 26505-3101

File Code: 3400
Date: April 27, 2010

Mr. Dan Balser
ODNR Division of Forestry
2045 Morse Road
Building H-1
Columbus, OH 43229-6693

Dear Dan:

Enclosed are 4 copies of the Seedling Survival Study on Abandoned Mine Lands in Eastern Ohio 2000-2009 report. Please give a copy to Lisa Bowers and two copies to the folks at Mines and Reclamation.

In brief, seedling mortality was approximately 40 percent during the first five years of the study but has decreased to approximately 7 percent during the last five years.

The two biggest threats to seedling survival on abandoned mine land in Ohio are invasive plant species and the emerald ash borer. Invasive species have already taken over one site and the emerald ash borer is now close to most of the sites.

Please call me at 304-285-1555 if you have any questions about the study or this report, or if you would like to tour the sites or discuss potential invasive species treatment options.

Sincerely,

Rodney L. Whiteman

RODNEY L. WHITEMAN
Forester
Morgantown Field Office

Enclosures

Cc: Dave Risley, ODNR DOW
Robert Lueckel, MFO